Columbia River Project Water Use Plan

KINBASKET AND ARROW LAKES RESERVOIR

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

Implementation Year 4

Reference: CLBMON-11B1

Study Period: 2013

Okanagan Nation Alliance, Westbank, BC

and

LGL Limited environmental research associates
Sidney, BC

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KINBASKET AND ARROW LAKES RESERVOIRS

Monitoring Program No. CLBMON-11B1
Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir




2013 Annual Report
Final

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

EXECUTIVE SUMMARY

CLBMON-11B1, initiated in 2009, is a long-term wildlife monitoring project that aims to assess the efficacy of revegetation prescriptions (i.e., CLBWORKS-2) in enhancing the suitability of habitats in the drawdown zone of Arrow Lakes Reservoir for wildlife, and to develop a minimum of three wildlife enhancement prescriptions that can be implemented in the drawdown zone to further improve habitat suitability (i.e., CLBWORKS-29B). The focal species groups selected for this study are songbirds, arthropods and mammals (ungulates). In addition to studying these groups, bats were incorporated into the 2010 sampling program because of the known relationships between bats, wetland and riparian habitat, and arthropods, which are their primary food source. In 2013 we sampled the same suite of wildlife than in previous years. Sampling occurred at control, treatment, and reference sites. Control sites are untreated (i.e., not revegetated) areas of the drawdown zone, treatment sites are areas where revegetation prescriptions have been applied, and reference sites are non-drawdown zone (i.e., upland habitats) that are monitored to document regional and natural variation in the taxa being studied.

There are three management questions (MQs) addressed by this monitoring program: (1) Are the revegetation and the wildlife physical works projects effective in enhancing wildlife habitat in the drawdown zone? (2) If the revegetation and the wildlife physical works projects enhance wildlife habitat in the drawdown zone, to what extent does the revegetation project and the wildlife physical works projects increase the productivity of habitat in the drawdown zone for wildlife? and (3) Are some methods or techniques more effective than others in enhancing wildlife habitat in the drawdown zone?

The revegetation prescriptions applied in the drawdown zone are likely to affect prey populations (i.e., terrestrial and aerial arthropods) before they affect the predators of those arthropods (songbirds and bats). The direction and magnitude of those changes in arthropod populations is being tracked over time and will serve as a metric to assess the efficacy of each revegetation prescription applied in the drawdown zone. Specific revegetation prescriptions (live stakes) may increase the volume of ungulate browse in the drawdown zone, which is why ungulates are included in the long-term monitoring program.

In general there does not appear to be a strong relationship between the biomass of arthropods or the relative abundance of songbirds and revegetation prescriptions applied in the drawdown zone. There were distinct groupings of both arthropods and songbirds that partitioned along an environmental gradient representing the drawdown zone and adjacent upland habitats and these groupings were consistent between 2010, 2011, and 2013. The inherent natural variation associated with songbirds and arthropods and the relatively short time since the revegetation prescriptions have been applied are likely contributing to the lack of observed patterns. More time is required to assess how species richness, biomass, and relative abundance change as a result of the implementation of the revegetation prescriptions.

The data suggest that songbirds and arthropods (certain spider and beetle families or species) are likely suitable indicators to assess changes in habitat quality induced by the revegetation prescriptions, but more time needs to pass

before those changes can be measured. This is based on the persistence of distinct drawdown zone and upland songbird and arthropod communities and on the relationships between songbirds and their arthropod prey. Although stochastic events appear to be affecting the biomass of arthropods (e.g., wind or rain events may have affected the total catch of arthropods in 2011 and 2013), a temporal data set consisting of multiple years should provide a smoothing effect and an indication of how arthropod biomass is changing and whether that change can be correlated to revegetated areas.

Ungulate use of the drawdown zone does not appear to be related directly to the revegetated areas. However, this is based on one or two aerial surveys per year in 2010 and 2011, which may not be representative of the actual use of the drawdown zone by ungulates. To resolve this, pellet plots were installed in 2011. These plots were counted and cleared in 2013 and results indicate that deer are using the drawdown zone to some degree, but use does not vary between control and treatment sites and is highly skewed towards controls sites in the drawdown zone. Continued monitoring of ungulates as an indicator of revegetation effectiveness is not recommended.

Monitoring the use of the drawdown zone by bats has resulted in the documentation of 10 species of bat in various locations in mid- and lower Arrow Lakes Reservoir. In 2013, the blue-listed Western small-footed myotis (*Myotis ciliolabrum*) was documented from Burton Creek, Beaton Arm, and Edgewood South and the blue-listed Townsend's big-eared bat (*Corynorhinus townsendii)* was documented at Burton Creek in 2013 (this species was detected at Edgewood South in 2011). The endangered Little-brown Myotis (*M. lucifugus*) was detected at Burton Creek, Beaton Arm, and Edgewood South. The relationship between bats and revegetation prescriptions has been difficult to assess, mainly because the data we collect is an indication species presence at each reach and not necessarily correlated with a specific treatment. Refinements to bat sampling are proposed to sample within treatment and control areas in future years.

Our ability to address each of the management questions is summarized below The methods used are appropriate for collecting data that can be used to answer certain questions. For others, additional approaches may be required. For example, to answer questions regarding songbird productivity, nest searches are suggested. In other cases, increasing the total area or number of areas revegetated would assist with problems associated with small sample size and small treatment areas. . Continued monitoring of arthropod, songbird, and bat, populations in the drawdown zone should provide the necessary information to answer most management questions. Future sampling for ungulates (via aerial surveys or pellet plots) is not recommended because of the limited influence the revegetation prescriptions are likely to have on ungulate populations. Evidence of use can be obtained by recording ungulate sign when sampling for other taxa. Sampling in each year will remove uncertainty associated with bi-annual sampling and better characterize the year-to year variation of all taxa sampled. Modifications to the study are suggested that will provide the data necessary to answer the management questions. Until the physical works are implemented in mid- and lower Arrow Lakes Reservoir, we will not be able to answer questions regarding their effectiveness.

MQ	Able to Address MQ?	Scope: Current supporting results	Scope: Suggested modifications to methods where applicable	Sources of Uncertainty
1. Are the revegetation and the wildlife physical works projects effective at enhancing wildlife habitat in the drawdown zone?	Partially	Data collected in control, treatment, and upland reference sites indicate that wildlife are using all treatment areas; however, the relatively short time (3 to 4 years) that has passed since the application of the revegetation prescriptions limits our ability to comment on the effectiveness of those prescriptions.	• Increased frequency of sampling (i.e., annually) • Pair autonomous acoustic monitors used to sample bats to sample control and treatment areas simultaneously	• Lack of appropriate baseline (sampling did not occur prior to the application of the revegetation prescriptions) • Natural annual population variation • Proximity of treatments to adjacent upland habitat • Lack of replication • Success of revegetation program • Bi-annual sampling • Variable reservoir operations • Physical works (i.e., those projects described in Hawkes and Howard 2012) have not been implemented
2. If revegetation and the wildlife physical works projects enhance wildlife habitat in the drawdown zone, to what extent does the revegetation program and the wildlife physical works projects increase the productivity of habitat in the drawdown zone for wildlife?	Not at this time	It is unclear if the revegetation prescriptions are effectively improving wildlife habitat. As such, it is too early to determine if productivity has increased. Data obtained in 2013 indicate that this may not be the case, at least for arthropods.	• Increased frequency of sampling (from biannually to annually) • Include nest searches to study bird productivity • Pair autonomous acoustic monitors to sample control and treatment areas simultaneously	• Lack of appropriate baseline (sampling did not occur prior to the application of the revegetation prescriptions) • Natural annual population variation • Lack of productivity surveys for songbirds (i.e., nest searches) • Bi-annual sampling • Variable reservoir operations • Physical works (i.e., those projects described in Hawkes and Howard 2012) have not been implemented
3. Are some methods or techniques more effective than others at enhancing wildlife habitat in the drawdown zone?	Not at this time	The application of treatment prescriptions in the drawdown zone do not support a treatment-specific assessment. The prescriptions applied were too small, not replicated, nor were they stratified.	• Consider adding replicates of certain revegetation prescriptions at some sites • Increase the size (total area treated) of some existing revegetation areas	• Lack of appropriate baseline (sampling did not occur prior to the application of the revegetation prescriptions) • Natural annual population variation • Variable reservoir operations • Physical works (i.e., those projects described in Hawkes and Howard 2012) have not been implemented

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

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ACRONYMS AND DEFINITIONS

To ensure that readers of this report interpret the terminology used throughout, the following definitions are provided. Definitions are presented in a logical, not alphabetical, order. These definitions follow those in Hawkes et al. (2011a).

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

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

EPL: excavator-planted live stake
EPL/HPL: excavator-planted live stake and hand-planted live stake
HPL: hand-planted live stake
PS: plug seedling

Reach: refers to a broad geographic area of the reservoir used as the highest level of stratification for sampling. The reaches, from north to south, are shown in Figure 3-1. They are Beaton Arm, East Arrow Park, Mosquito Creek, Burton Creek, Lower Inonoaklin Road, Edgewood North and Edgewood South.

Within each reach, sampling was conducted in control, treatment and reference sites (collectively referred to as treatments). These terms are defined as follows:

Control Site: area of the drawdown zone that was not revegetated using the revegetation prescriptions developed for CLBWORKS-2. Control polygons were placed in areas of similar elevation, topography and substrate as treatment polygons.

Treatment Site: area of the drawdown zone that was revegetated using one of the seven revegetation prescriptions developed for CLBWORKS-2.

Reference Site: sampling location outside of the drawdown zone and adjacent to control and treatment sites. One of the functions of the reference sites is to allow for interpretation of naturally occurring changes in the relative abundance, diversity, richness or other metric associated with one or more of the focal groups over time. Reference sites could also be areas within the drawdown zone that represent a desired condition.

Drawdown Zone: the terrestrial portion of the reservoir that is inundated and exposed due to changing reservoir elevations.

Experimental Block: pairing of a treatment site with a control site. The experimental block established at reaches where revegetation prescriptions were applied consists of the revegetation polygon and a control polygon that is the same size and configuration as the treatment polygon.

Control and treatment sites were established in four broad elevation strata (modified from Keefer et al. 2009):

High elevation:	> 438 m ASL
Medium elevation:	436–438 m ASL
Low elevation:	434–436 m ASL
Lowest elevation:	< 434 m ASL

The high, medium, and low elevation strata matched those used by Keefer et al. (2009). The lowest elevation stratum was added because wildlife sampling was not constrained to elevations > 434 m ASL.

Season: In the context of CLBMON-11B1, seasons are defined as spring (April and May), early summer (June through mid-July), late summer (mid-July through mid-August) and late summer (mid-August to early September).

1.0 INTRODUCTION

The Columbia River Water Use Plan was developed as a result of a multi-stakeholder consultative process to determine how to best operate BC Hydro's Mica, Revelstoke and Keenleyside facilities to balance environmental values, recreation, power generation, culture/heritage, navigation and flood control. The goal of the Water Use Plan is to accommodate these values through operational means (i.e., patterns of water storage and release) and non-operational physical works in lieu of changing reservoir operations to address specific interests. During the Water Use Planning process, the Consultative Committee supported the implementation of physical works (revegetation and habitat enhancement) in the mid-Columbia River in lieu of changing reservoir operations to help mitigate the impact of Arrow Lakes Reservoir operations on wildlife and wildlife habitat. In addition, the Consultative Committee recommended the use of monitoring to assess the effectiveness of these physical works in enhancing habitat for wildlife.

This recommendation resulted in the development of CLBMON-11B1, an 11-year monitoring program comprised of two distinct components:

1. CLBMON-11B: Revegetation effectiveness monitoring; and
2. CLBWORKS-29B: Wildlife enhancement prescriptions for mid- and lower Arrow Lakes Reservoir.

These two components were combined to assess the efficacy of revegetation prescriptions, to enhance wildlife habitat using a focal species approach, and to identify opportunities to enhance the suitability of wildlife habitat in the drawdown zone of mid- and lower Arrow Lakes Reservoir.

An effectiveness monitoring program should be designed to determine how well management activities, decisions, or practices meet the stated objectives of the program (Marcot 1998, Noon 2003). Key to designing an effectiveness monitoring program is the selection of statistically testable response variables that are appropriate to the objectives of the management action (Machmer and Steeger 2002); however, the selection of indicators (e.g., focal species) can be challenging (Andersen 1999). The selection of indicator species/processes should be guided by their sensitivity to the management practice, the ease of collecting data, and the usefulness of the information to address the management activity (Chase and Guepel 2005). Potential indicators may include habitat attributes, keystone species, species at risk, species that are sensitive to specific habitat requirements, or species that can be monitored easily (Feinsinger 2001, Chase and Guepel 2005). The selection of indicators should also be appropriate to the spatial scale of the applied management activity, and must take into consideration factors that are external to the monitoring program, such as inter- and intra-specific competition, predation, climatic change, disease, time of year, and in the case of CLBMON-11B1, normal reservoir operations.

In 2009, LGL completed a reconnaissance-level study of wildlife using the drawdown zone of Arrow Lakes Reservoir; the study focused on terrestrial arthropods, songbirds and mammals. The results of that study are presented in Hawkes et al. (2010). The first year of monitoring occurred in 2010 (see Hawkes et al. 2011). This report summarizes the results of the second year of monitoring (2011a) of CLBMON-11B1 and includes information on the use of the drawdown zone by terrestrial arthropods, songbirds and terrestrial mammals and the relationship of those species groups to the various revegetation prescriptions applied between 2009 and 2011 (CLBWORKS-2). Options for wildlife enhancement strategies (i.e., CLBWORKS-29B) were submitted as a stand-alone report (Hawkes and Howard 2012). CLBWORKS-29B provides prescriptions to improve wildlife habitat in and immediately adjacent to the drawdown zone of mid- and lower Arrow Lakes Reservoir.

2.0 OBJECTIVES AND MANAGEMENT QUESTIONS

CLBMON-11B1 incorporates two projects: CLBMON-11B and CLBWORKS-29B. Collectively, the components of both projects are captured under the umbrella of CLBMON-11B1. The objectives of CLBMON-11B (modules 1 and 2[1]) are to determine the efficacy of revegetation efforts and wildlife habitat enhancement or protection efforts in increasing the suitability of wildlife habitats in the drawdown zone of mid- and lower Arrow Lakes Reservoir. The enhancement prescriptions developed for mid- and lower Arrow Lakes Reservoir (CLBWORKS-29B) will be designed to either protect existing habitat features that provide high-value wildlife habitat or to enhance/create those features within the drawdown zone. CLBMON-11B involves acquiring data on ungulates, songbirds and terrestrial arthropods.

In addition to assessing the overall effectiveness of the revegetation and wildlife physical works projects, CLBMON-11B1 will facilitate an adaptive management approach to habitat enhancement. Adaptive management is an iterative process designed to improve the rate of learning with respect to managing complex systems (Taylor et al. 1997, Murray and Marmorek 2004). The process incorporates an explicit acknowledgement of uncertainties and knowledge gaps about the response of the system to management actions, and attempts to reduce those uncertainties through structured monitoring of those management actions (e.g., treatments). The underlying tenet of "learning by doing" lends itself well to ecosystem restoration and habitat enhancement. This approach has been embraced by practitioners of ecosystem restoration (see Douglas 2003, Clewell et al*.* 2005, Patten 2006).

The Water Use Plan Consultative Committee provided the following direction with respect to the revegetation and wildlife physical works effectiveness monitoring program (BC Hydro 2007):

Project Description: To monitor wildlife utilization patterns in response to revegetation efforts in Kinbasket Reservoir, Mid-Columbia River and Arrow Lakes Reservoir.

Rationale: "There is uncertainty about current utilization of the drawdown zone by wildlife species and the effects of reservoir operations. Monitoring will inform on the effects of revegetation efforts in Kinbasket and Arrow Lakes Reservoirs on wildlife utilization patterns and the effectiveness of Arrow Lakes Reservoir physical works on wildlife habitat quality and quantity".

The overall scope of this study is to address whether revegetation and wildlife physical works are effective in enhancing wildlife habitat in lieu of changing reservoir operations.

[1] CLBMON-11B includes two of three modules (1 and 2). Module 3 is a stand-alone project that focuses specifically on Revelstoke Reach.

The combined objectives of CLBMON-11B (modules 1 and 2) and CLBWORKS 29B (collectively referred to as CLBMON-11B1) are as follows:

1. Develop a monitoring program to assess the effectiveness of the revegetation program (CLBWORKS-2) and wildlife physical works projects (CLBWORKS-30) in enhancing wildlife habitat in the drawdown zone of Arrow Lakes Reservoir.
2. Monitor the appropriate biological indicators and response variables to assess the effectiveness of the revegetation and wildlife physical works programs in enhancing wildlife habitat in the drawdown zone.
3. Provide recommendations on the effectiveness of the revegetation program and wildlife physical works projects in improving habitat for wildlife in the drawdown zone.
4. Identify high-value habitat along the drawdown zone of the lower and middle reaches of the Arrow Lakes Reservoir for protection.
5. Identify habitat enhancement opportunities along the drawdown zone of the lower and middle reaches of the Arrow Lakes Reservoir.
6. Provide recommendations for enhancing or protecting high-value wildlife habitat along the drawdown zone of the lower and middle reaches of the Arrow Lakes Reservoir.
7. Prepare a minimum of three habitat enhancement/restoration plans.

2.1 Management Questions

CLBMON-11B1 is designed to assess the wildlife habitat effectiveness of the revegetation program (CLBWORKS-2), guide the development of CLBWORKS-30, and assess the effectiveness of the resulting wildlife physical works in enhancing wildlife habitat in the drawdown zone of Arrow Lakes Reservoir. Monitoring under CLBMON-11B1 will evaluate the response of several wildlife taxa and habitat elements to alterations made to the drawdown zone by the revegetation and wildlife physical works programs. The findings of this study will help improve the effectiveness of revegetation and physical works projects through the use of an adaptive management approach.

This monitoring program will address three management questions:

1. Are the revegetation and the wildlife physical works projects effective at enhancing wildlife habitat in the drawdown zone?
2. If revegetation and the wildlife physical works projects enhance wildlife habitat in the drawdown zone, to what extent does the revegetation program and the wildlife physical works projects increase the productivity of habitat in the drawdown zone for wildlife?
3. Are some methods or techniques more effective than others at enhancing wildlife habitat in the drawdown zone?

2.2 Management Hypotheses

The hypotheses address the revegetation and wildlife physical works projects independently and will address the management questions listed above.

HA_1: Revegetation does not change wildlife use of the drawdown zone.

HA_{1A}: Revegetation does not change the area (m^2) or increase the suitability of wildlife habitat in the drawdown zone.

HA_{1B}: Revegetation does not change the utilization of the drawdown zone by songbirds as measured by species diversity and/or relative abundance.

HA_{1C}: Revegetation does not change the utilization of the drawdown zone by ungulates as measured by indices of use (e.g., pellet counts, browse, tracks and occupancy).

HA_{1D}: Revegetation does not change the utilization of the drawdown zone by amphibians and reptiles as measured by occupancy and/or relative abundance (e.g., presence/absence and catch per unit effort).

HA_{1E}: Revegetation does not change the abundance (e.g., biomass) and species diversity in the drawdown zone of terrestrial arthropods, which are prey for amphibians and reptiles, birds and mammals.

HA_2: Wildlife physical works does not change wildlife use of the drawdown zone.

HA_{2A}: Wildlife physical works projects do not change the area (m^2) or increase the suitability of wildlife habitat in the drawdown zone.

HA_{2B}: Wildlife physical works projects do not change the utilization of the drawdown zone by birds (including raptors, songbirds, waterbirds and shorebirds) as a measure of increased species diversity, abundance and productivity.

HA_{2C}: Wildlife physical works projects do not change the utilization of the drawdown zone by Painted Turtles and other amphibians and reptiles as a measure of occupancy, abundance and productivity (e.g., presence/absence, catch per unit effort, breeding success).

HA_{2D}: Wildlife physical works projects do not change the abundance (e.g., biomass) and species diversity in the drawdown zone of invertebrates, which are prey for amphibians and reptiles, birds and mammals.

HA_3: The methods and techniques employed do not result in changes to wildlife habitats in the Arrow Lakes Reservoir drawdown zone.

HA_{3A}: The revegetation methods do not result in changes to wildlife habitat in the drawdown zone as measured by indices of habitat suitability, site productivity (e.g., arthropod biomass) and forage production.

HA_{3B}: The methods used for wildlife physical works do not result in changes to wildlife habitat in the Arrow Lakes Reservoir drawdown zone as measured by indices of habitat suitability, site productivity (e.g., arthropod biomass) and forage production.

The hypotheses and objectives of this study are more easily discussed in terms of broad themes that encapsulate the hypotheses and objectives for CLBMON-11B or CLBWORKS-29B (Table 2-1).

Table 2-1: The broad themes and hypotheses addressed by each theme for each component of CLBMON-11B1. An X indicates a relationship between the theme and hypothesis. Bold and shading indicates the focus of this annual report

		Hypotheses													
Theme	**Component**	**HA_1**	**HA_{1A}**	**HA_{1B}**	**HA_{1C}**	**HA_{1D}**	**HA_{1E}**	**HA_2**	**HA_{2A}**	**HA_{2B}**	**HA_{2C}**	**HA_{2D}**	**HA_3**	**HA_{3A}**	**HA_{3B}**
1. Revegetation, wildlife and wildlife habitat	**11B**	**X**	**X**	**X**	**X**	**X**	**X**								
2. Revegetation and changes to productivity	**11B**													**X**	
3. Revegetation: a comparison of techniques	**11B**												**X**		
4. Physical works	29B							X	X	X	X	X			X

2.3 Key Water Use Decisions Affected

The Terms of Reference for CLBMON-11B1 indicate that the results of this study will aid in more informed decision-making with respect to the need to balance the requirements of wildlife that are dependent on wetland and riparian habitats with other values such as recreational opportunities, flood control and power generation. The key water use planning decisions affected by the results of this monitoring program are whether revegetation and wildlife physical works are more effective in enhancing wildlife habitat than are changes to reservoir operations. Results from this study will also assist in refining the approaches and methods for enhancing wildlife habitat through adaptive management.

3.0 STUDY AREA

The Hugh Keenleyside Dam, completed in 1968, impounded two naturally occurring lakes to form the Arrow Lakes Reservoir, an approximately 230-km long section of the Columbia River drainage between Revelstoke and Castlegar, B.C. (Figure 3-1; Carr et al. 1993, Jackson et al. 1995). Two biogeoclimatic zones occur within the study area: the Interior Cedar Hemlock (ICH) and the Interior Douglas-fir (IDF). The reservoir has a north-south orientation, and is set in the valley between the Monashee Mountains in the west and Selkirk Mountains in the east. Arrow Lakes Reservoir has a licensed storage volume of 7.1 million acre feet (BC Hydro 2007). The normal operating range of the reservoir is between 418.64 m and 440.1 m above sea level (m ASL).

For CLBMON-11B1, the area of interest within Arrow Lakes Reservoir is the drawdown zone between Beaton Arm and Castlegar (Figure 3-1). For certain species groups (e.g., songbirds and terrestrial arthropods), those portions of the drawdown zone where revegetation prescriptions were applied under CLBWORKS-2 are the focal areas. For mammals (e.g., ungulates and winter furbearers), the entire drawdown zone from Revelstoke to Castlegar on both the east and west sides of the reservoir comprise the study area.

In 2010, seven areas within the drawdown zone of Arrow Lakes Reservoir were selected for monitoring (vs. six in 2009; Figure 3-1). Lower Inonaklin Road was added after 2009. Site selection was based on those areas treated under CLBWORKS-2 (Keefer et al. 2009), on areas within the drawdown zone that will not be treated under CLBWORKS-2 where potential wildlife enhancement projects could occur (e.g., Lower Inonoaklin), and areas that represent habitats in the drawdown zone that could be considered climax communities (relative to those that could develop in the drawdown zone). These sites were monitored again in 2013.

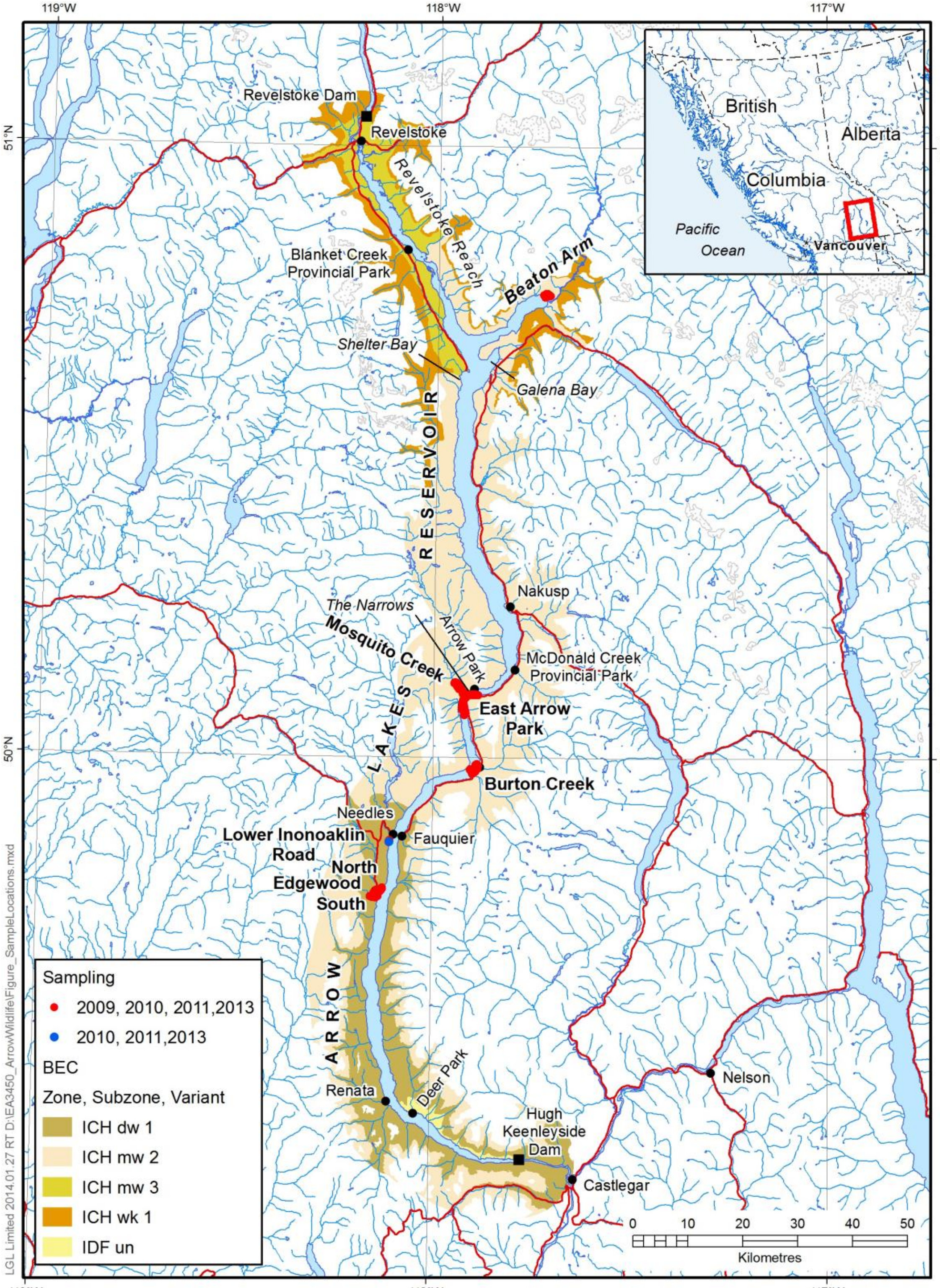

Figure 3-1: Location of Arrow Lakes Reservoir in B.C. and reaches sampled in 2013

4.0 METHODS

4.1 2013 Field Sampling Schedule

The timing of the 2013 sampling sessions (Table 4-1) coincided with the period during which terrestrial arthropods, birds, and bats would be active. Sampling occurred during similar periods as in previous years.

Table 4-1: Dates and reservoir elevations of each 2013 field session (FS). A = available; NA = not available

						Strata Elevation (m ASL)			
	2013		Reservoir Elevation (m ASL)			Lowest	Low	Medium	High
FS	Start Date	End Date	Min	Max	Mean	< 434	434–436	436–438	> 438
1	May 18	May 27	433.24	434.5	433.88	A	A	A	A
2	June 4	June 12	435.18	436.6	435.86	NA	NA	A	A
3	June 21	June 30	438.35	439.67	439.11	NA	NA	NA	A
4	July 13	July 18	437.96	438.86	438.38	NA	NA	A	A

4.2 Songbirds

Time-constrained, variable-radius[2] point count surveys were used to assess the diversity and relative abundance of songbirds (Ralph et al. 1995). The timing of the songbird surveys (mid-May to mid-June) coincided with the arrival of most songbird species in the general area and the height of the breeding season at which time all locally breeding birds are on territory and are highly vocal, enabling surveyors to accurately document the number and diversity of migrating and/or breeding birds. Three visits to each point count were scheduled to permit the calculation of a detection rate for each species at each point count. Surveys commenced at sunrise and ended within ~4 hours of sunrise (Ralph et al. 1995). Songbird surveys were done during favourable conditions only (i.e., no heavy wind or precipitation) to standardize surveys and minimize variable detections associated with sub-optimal environmental conditions.

The point count survey method involves standing at a fixed point within each control, treatment, and reference site and documenting all birds seen and/or heard within 75 m of the observer during a 6-minute count period. Individual point counts were placed at ~150 m intervals to eliminate multiple detections of the same bird from more than one point count station during each survey. The species of bird as well as the distance (from the observer) were recorded. Additional data recorded included the sex and age class of the bird (when known) and the type of detection (call, song, or visual), and notes were made to differentiate fly-over birds from the rest of the detections. Furthermore, because the detectability of different bird species varies depending on the amount of time devoted to each survey (Bibby et al., 2000), the portion of the 6-minute count period in which each individual is detected was recorded (0-3 minutes, 3-5 minutes, 5-6 minutes).

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

1. **Physical information:** site number, point count number, GPS coordinates, weather (wind speed, temperature, relative humidity [measured with a

[2] Variable in the sense that data are recorded at varying distances from the point count centre

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), 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 (sight or sound);
3. **Bird observations outside point count plots:** incidental observations of birds located outside the point count area at each site.

In 2013 we continued to sample songbirds using the 75 m variable radius point count method, but used only songbirds documented within 30 m of the point count centre when investigating potential treatment effects (which follows the approach taken in 2011; Hawkes et al. 2012).

4.3 Terrestrial Arthropods

Terrestrial arthropods were sampled using most of the same methods as in 2010 and 2011 (Hawkes et al. 2011a). The main methods used were pitfall traps and Malaise traps. Given the dearth of results associated with light traps in 2011 (Hawkes et al. 2012), we did not deploy them in 2013. In 2010 we sampled between May and August to determine the seasonal distribution and occurrence of arthropods in the drawdown zone and to define the period during which the biomass of insects was the greatest. Based on the results obtained in 2010 we deployed Malaise and pitfall traps in May, June, and July in 2011 (to coincide with songbird sampling) and light traps in August and September (to coincide with bat sampling). Malaise and pitfall traps were deployed again in May, June and July of 2013 (to coincide with songbird sampling), but light traps were not used. Arthropod samples were collected over a four day period. A biomass sample was collected after the first three days and a one day sample was collected on the last day. The biomass samples were tallied and identified to order or family (Diptera, Hymenoptera) or species (Coleoptera) when possible and placed in a drying oven to obtain a dry weight. The one day samples were tallied and identified to order or family (Diptera, Hymenoptera) or species (Araneae, Coleoptera, Orthoptera) when possible.

The three day samples were weighed and placed in a drying oven for 48 hrs to dry. The dried samples were then once again weighed to obtain the dry weight of each sample. The biomass associated with each trap type, reach, and site was kept separate for comparative purposes.

4.3.1 Pitfall Trapping

Pitfall arrays were comprised of three traps inserted into the ground at 1 m intervals. Because each array covered 5 m^2, it was possible to replicate the number of arrays per treatment, thereby increasing the sample size associated with each treatment or control polygon. Each 5 m^2 location was randomly selected within each treatment and control polygon in a GIS by first overlaying a 5 m x 5 m grid on each treatment polygon and then randomly selecting 5 m x 5 m grids for sampling. In this way, pitfall arrays could be paired between treatment and control sites. All data collected in all arrays within a given treatment or control polygon were pooled for analyses. Maps depicting the location of pitfall traps in 2013 are provided in Appendix 10-A.

4.3.2 Malaise Traps

Malaise traps were established in control, treatment and reference locations at all reaches (except Lower Inonoaklin Road). Sample locations were selected randomly using the same method as pitfall trap site selection. Maps depicting the location of Malaise traps in 2013 are provided in Appendix 10-A.

4.4 Mammals

4.4.1 Terrestrial Mammals

Terrestrial mammal observations (visual sightings, wildlife signs) were documented in control, treatment and reference sites in 2013. This included recording the location of species observed in the drawdown zone, the location of pellet groups and the location of other mammal signs (e.g., bones, hair, scat). This general approach was consistent with the methods used by Hawkes et al. (2010, 2011a, 2012). We also documented the location of unique wildlife habitat features, such as mineral licks or animal dens.

Circular pellet plots (1.71 m radius; area = 9.2 m^2) were installed in control and treatment polygons at Burton Creek, Edgewood South, and Lower Inonoaklin Road. Five or six pellet plots were established per control and treatment polygon at each reach; the number of pellet plots was a function of the size of the treatment area. Pellet plots were established and cleared in June 2011 (see Appendix 10-B for locations). All pellet plots established in 2011 were counted and cleared again in 2013.

4.4.2 Bats

Song Meter SM2BAT 192kHz Stereo Ultrasonic Recorder units (Wildlife Acoustics, Inc.; Figure 4-1) were deployed between mid-July and the end of September to record bats feeding in the drawdown zone at six sites. Each bat detector was programmed to record between 7:30 p.m. (just prior to sunset) and 1:00 a.m. and then again from 5:00 a.m. (approximately one hour before sunrise) to 6:00 a.m. Bat detectors were deployed at Mosquito Creek, Edgewood South, Burton Creek, and Beaton Arm (i.e., two treatment areas and two non-treated areas). At Edgewood South and Burton Creek the bat detectors were situated in or angled toward a live stake treatment (EPL, EPL/HPL, or HPL) prescription. At Mosquito Creek, a bat detector was deployed to document activity over the drawdown zone along the creek. At Beaton Arm, one unit was positioned near one of the beaver ponds but was angled out to record activity over the drawdown zone.

Figure 4-1: Example of a typical Song Meter SM2BAT unit set-up on an elevated feature with the microphone aimed in the direction of the desired habitat

Under ideal conditions the bat detectors will detect bats in an airspace of 30 to 100 m from the microphone, with bats emitting higher frequencies (*Myotis septentrionalis*; Table 4-2) detected more often in the 30 m zone and bats emitting lower frequencies (e.g., *Lasionycteris noctivagans and Lasiurus cinereus*; Table 4-2) detected out to ~100 m from the microphone. The microphone paired with the SM2BAT+ is an omnidirectional[3] microphone, meaning that it will sample from almost all directions projecting out from the microphone (Figure 4-2).

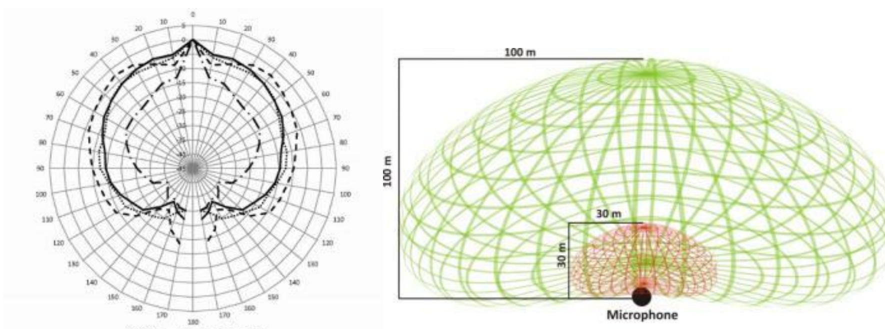

Figure 4-2: Representation of the bat detector sampling area relative to a compass rose (left) and to the distances over a which the probability that a high (red ellipse) and low frequency (green ellipse) bat species would be detected is greatest (right). Image on left courtesy of Wildlife Acoustics, Inc. Image on right, LGL Limited**.**

Table 4-2: Typical frequencies (kHz) associated with a selection of bat species expected to occur in habitats associated with the drawdown zone of Kinbasket Reservoir.

Frequency (kHz)	*Myotis lucifugus*	*M. evotis*	*Eptesicus fuscus*	*Lasionycteris noctivagans*	*Lasiurus cinereus*	*M. septentrionalis*	*M. volans*
Characteristic frequency	40 - 43	33 - 37	27 - 31	25 - 28	19 - 24	40 - 46	40 - 44
Highest apparent frequency	70 - 94	71 - 97	49 - 66	36 - 53	20 - 39	90 - 116	77 - 100
Lowest apparent frequency	35 - 40	26 - 30	26 - 30	24 - 27	19 - 24	32 - 41	34 - 39

[3] The microphone can record in all directions, but the sensitivity is weakest between ~ 160 and 200°

4.4.3 Winter Mammal Surveys

Based on recommendations in Hawkes et al. (2012), winter mammal surveys were not conducted in 2013.

4.5 Data Analyses

There are 14 hypotheses that can be grouped into four broad themes. In general, data analyses performed in 2013 were the same as those in 2009 and 2010 (Hawkes et al. 2010, 2011a). However, because 2013 represented the fourth year of the study, we were able to make some preliminary comparisons between years, primarily to assess the level of natural variation in songbird and arthropod communities. Most of the results reported summarize the data collected in 2013 and do not assess (in detail) temporal trends. The analyses performed in 2013 aimed to do the following:

1. continue to characterize the fauna (i.e., songbirds, arthropods, mammals, and amphibians and reptiles) in the drawdown zone of mid- and lower Arrow Lakes Reservoir;
2. compare (where possible) the relative abundance and species richness of songbirds and arthropods among the various combinations of reaches and treatments between years;
3. relate the biomass of certain orders of arthropods (those eaten by insectivorous songbirds) calculated for 2013 to the songbird species that would prey on those orders; and
4. determine if the songbird and arthropod assemblages associated with drawdown and adjacent upland habitats documented in previous years (2009, 2010, and 2011) persisted in 2013.

Songbird data were assessed for community similarity between reaches and treatments and measures of diversity, richness, and relative abundance (detection rates) were calculated. Songbird data were assessed with boxplots, ANOVAs (tested with 99,999 permutations), Principal Coordinates Analysis (PCoA), and the computation of concordance *W*, K-means and Principal Components Analysis (PCA) (all computed in the R language (version 3.0.2). The identification of clusters of species allows an investigation of the ecological requirements that are common to the cluster rather than evaluating the ecological needs of each species individually (Legendre 2005). Kendall's coefficient of concordance *W* is a measure of the agreement among several species that are assessing a given set of *n* objects (Legendre 2005), which in this case are the treatments.

As in previous years, two different association coefficients were used to compute the similarity songbird communities between treatments and reaches: the Bray-Curtis distance (D14[4]) and the Hellinger transformation followed by Euclidian distances (D17-D1). To calculate concordance *W*, K-means and PCA, only species that occurred in at least two reaches or treatment types were included in the analyses. The *W* coefficient and K-means partitions were tested with 100,000 permutations. Species richness, relative abundance, diversity and evenness of songbirds were compared among treatment types and reaches through boxplots

[4] D is a distance matrix produced by the transformation of ecological data. See Legendre and Gallagher (2001).

and one- and two-way ANOVAS (comparing metrics of richness, diversity, and similarity between reaches with 9,999 and 99,999 permutations, respectively).

4.5.1 Terrestrial Arthropods

Arthropod species richness, diversity, and community similarity were compared among treatments within each reach (Hawkes et al. 2010, 2011a, 2012). The same process as described above for birds was used in 2009 (Year 1), but in 2010 and 2011 the biomass samples were not tallied or sorted (see Hawkes et al. 2012). In 2013, the arthropod samples from the malaise and pitfall traps were again sorted and identified to order or family. Specimens of ground beetles (Coleoptera: Carabidae) and rove beetles (Coleoptera: Staphylinidae) were identified to lower taxonomic levels (Subfamily, Genus, or Species) and Araneae (spiders) were identified to species because of their potential use as indicators to assess habitat changes associated with the application of revegetation prescriptions in the drawdown zone of mid- and lower Arrow Lakes Reservoir.

4.5.2 Songbirds

Songbird analyses followed those described in Hawkes et al. (2011a) with several minor changes including:

1. species richness and relative abundance were compared among years, treatment types and reaches with boxplots and ANOVAs;
2. relative abundance was computed by adding up the counts of each species over all the visits to a point count and dividing by the number of visits to the point count that year. Point counts that had no counts but that were visited on at least one occasion were included; and
3. species richness was computed as the total number of species observed at a point count divided by the number of visits made to the point count to correct for sampling effort.

4.5.3 Mammals

4.5.3.1 Terrestrial mammals

Data analyses for terrestrial mammals were limited to an assessment of the distribution of species and species richness by reach and treatment. Because few mammal observations in the drawdown zone were within revegetation or control polygons, comparisons between control and treatment sites were not possible.

4.5.3.2 Bats

Bat presence and activity was assessed by analysing the .wav files recorded by each bat detector using Kaleidoscope (Wildlife Acoustics). Kaleidoscope is an integrated suite of bat data tools designed to quickly convert files, sort and categorize bat data by species, verify findings, visualize the data collected and easily transform it into reports. Bat species richness was summarized for each sampling location and the relative level of activity (determined by the number of recordings attributed to a given species) was assessed for each location. Data collected by autonomous recording devices do not provide an indication of the number of individual bats present in a given area and the assignment of species is based on a probability that the species is present.

4.6 Habitat Enhancement Strategies

The development of wildlife physical works prescriptions was accomplished through an assessment of wildlife data collected for CLBMON-11B1 and an evaluation of where physical works projects could be feasibly be implemented (see Hawkes and Howard 2012).

5.0 RESULTS

5.1.1 Environmental Conditions

Environmental conditions can affect the activity of some animals. Specifically, temperature, precipitation, precipitation, and to a lesser extent relative humidity. A visual assessment of plots of these parameters over the last three years suggests that environmental conditions were consistent from year to year (Figure 5-1). The level of variation observed is consistent with seasonal changes and is not considered sufficient to affect the activity levels of the focal taxa being studied, and thus, unlikely to have influenced detectability measures.

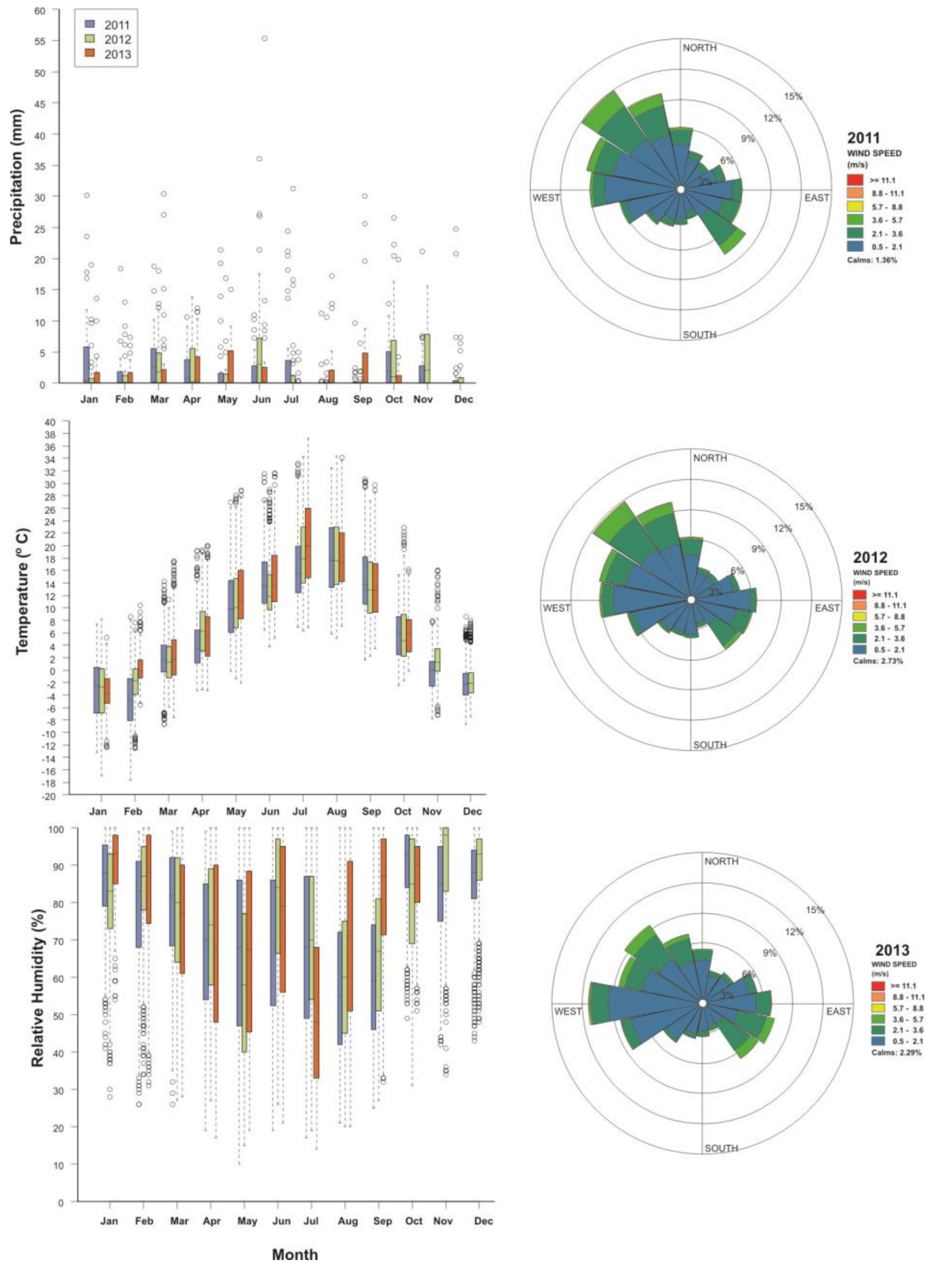

Figure 5-1: Average monthly precipitation, temperatures relative humidity, and wind direction (flow vectors, i.e., the direction the wind is blowing to) recorded at Falls Creek, Arrow Lakes Reservoir

5.1.2 Reservoir Conditions

The elevation of Arrow Lakes Reservoir ranged from a low of ~433 m ASL during field session 1 to a high of ~ 439 m ASL during field session 3 (Table 4-1). Arrow Lakes Reservoir reached a maximum of 439.72 m ASL on July 7, 2013. Reservoir elevations did impact our ability to sample songbirds and arthropods from some stations during field session 2, 3, and 4 (Table 4-1). However, they did not impact ability to count and clear pellet plots, particularly those in the drawdown zone, but they limited access to certain reaches in late summer to sample bats.

Reservoir elevations in 2013 were lowest between February and the beginning of May (Figure 5-2), and as such, substantial areas within the drawdown zone were available for sampling. Water levels increased fairly rapidly after the first week of May, peaking at the end of the first week of July. Reservoir levels began to drop immediately following peak on July 7, 2013. The pattern of reservoir elevation fluctuations has been fairly consistent over the last four years (Figure 5-2).

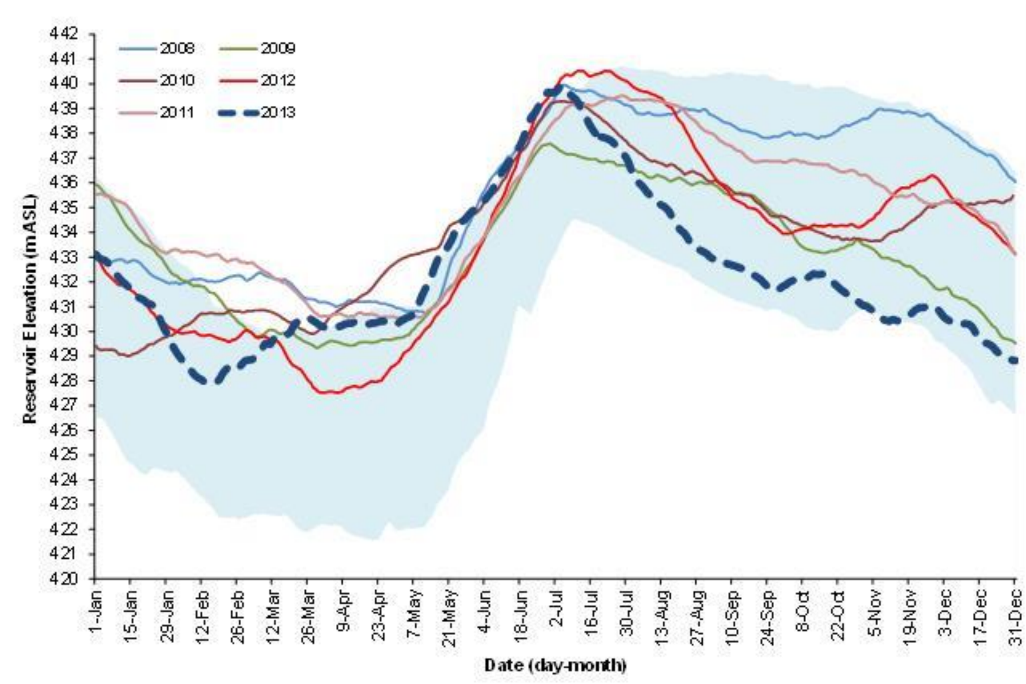

Figure 5-2: Arrow Lakes Reservoir elevations [metres above sea level (m ASL)] for 2008 to 2013. Also shown are the 10th and 90th percentiles (shaded area) for the 45-year average (1969–2013)

5.2 Wildlife Effectiveness Monitoring

5.2.1 CLBWORKS-2 and Revegetation Effectiveness Monitoring

Revegetation prescriptions (CLBWORKS-2) were applied between 2008 and 2011 and the total area revegetated per year ranged from 2.13 ha in 2008 to 36.22 ha in 2009. The plug seedling prescription was the most commonly applied prescription (39.84 ha) followed by hand-planted live stakes (23.31 ha). All other prescriptions were either applied either over relatively small areas or in one year only. Both plug seedling and hand-planted live stakes prescriptions were used in all reaches sampled for CLBMON-11B1. Examples of the types of revegetation prescriptions applied in the drawdown zone of Arrow Lakes Reservoir are shown in Figure 5-3.

Table 5-1: Total hectares of revegetation prescriptions applied at various sites in mid- and lower Arrow Lakes Reservoir 2008-2011. ATVS: all-terrain vehicle seeding; EPL: excavator-planted live stake; EPL/HPL: excavator-planted live stake and hand-planted live stake; HPL: hand-planted live stake; PS: plug seedling; PS-Fert: plug seedling with fertilizer application; Fert: fertilizer application only (no other revegetation prescription applied)

Year	Reach	ATVS	EPL	EPL/HPL	HPL	PS	PS-Fert	Fert	Total
2008	Burton Creek					0.16	0.06	1.64	1.87
	Nakusp					0.26			0.26
	2008 Totals					**0.42**	**0.06**	**1.64**	**2.13**
2009	Burton Creek		0.15	1.22		4.81			6.17
	Eagle Creek		1.07						1.07
	East Arrow Park	1.38			3.03	10.81			15.22
	Edgewood South			0.19		2.71			2.91
	Lower Inonoaklin		0.76	0.87		1.74			3.37
	Nakusp					7.47			7.47
	2009 Totals	**1.38**	**1.98**	**2.28**	**3.03**	**27.54**			**36.21**
2010	Burton Creek					2.1			2.1
	East Arrow Park					4.02			4.02
	Renata					5.76			5.76
	2010 Totals					**11.88**			**11.88**
2011	Beaton Arm				1.46				1.46
	Burton Creek				7.68				7.68
	East Arrow Park				5.78				5.78
	Edgewood				0.81				0.81
	Lower Inonoaklin				4.54				4.54
	2011 Totals				**20.27**				**20.27**
	4-yr totals	**1.38**	**1.98**	**2.28**	**23.3**	**39.84**	**0.06**	**1.64**	**70.5**

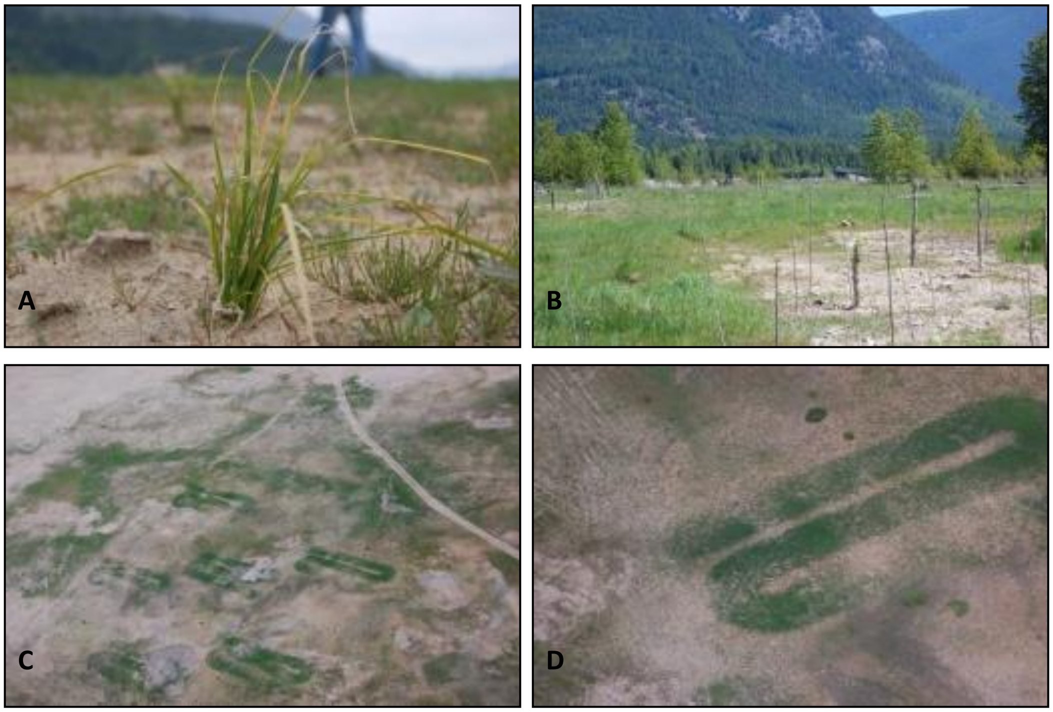

Figure 5-3: Examples of various revegetation prescriptions applied in the drawdown zone of Arrow Lakes Reservoir in 2009. A: sedge plug; B: live stakes; C: overview of fertilizer and seedling trial and Burton Creek; D: close up of fertilizer trial at Burton Creek

Although both hand-planted live stakes and plug seedling prescriptions have been applied in all reaches sampled (with the exception of Beaton Arm and Mosquito Creek), sample size was limiting because of the way the revegetation applications were implemented. For example, the total area revegetated per reach varied, not all prescriptions were applied at all reaches, and there was no within-reach replication. At present there is nothing we can do to mitigate these issues. Any assessment of treatment effects can be reach-specific only.

5.2.2 Terrestrial Arthropod Sampling

Arthropod surveys using Malaise and pitfall traps were conducted between May 19 and 26 and again between June 5 and 12, 2013. Arthropod sampling was accomplished only through the use of Malaise and pitfall traps. Total sampling effort was 558.5 trap nights (Malaise: 91.5 nights; pitfall: 467.0 nights; Table 5-2). Sampling was mostly equally distributed among treatments and the most nights of trapping were conducted at Burton Creek, followed by East Arrow Park. The differences in trapping effort were related primarily to the number of treatments applied and to the total area treated.

Table 5-2: Distribution of trap nights by reach, method and treatment in the Arrow Lakes Reservoir. Sites with the same number (e.g., BU01 C and BU01 T) were paired samples. See Section 4.0 for definitions of treatments

		Trap Nights per Method		
Reach Name	**Treatment & Site**	**Malaise**	**Pitfall**	**Total**
Beaton Arm	Drawdown Zone	8.0	37.0	**45.0**
	Reference	7.0	35.0	**42.0**
Beaton Arm Total		**15.0**	**72.0**	**87.0**
Burton Creek	BU01 C	5.0	25.0	**30.0**
	BU01 T	5.0	25.0	**30.0**
	BU02 C	5.0	25.0	**30.0**
	BU02 T	5.0	25.0	**30.0**
	Reference	4.0	26.0	**30.0**
Burton Creek Total		**24.0**	**126.0**	**150.0**
East Arrow Park	EA01 C	3.5	20.0	**23.5**
	EA01 T	3.5	20.0	**23.5**
	EA02 C	4.0	20.0	**24**
	EA02 T	3.5	20.0	**23.5**
East Arrow Park Total		**14.5**	**80.0**	**94.5**
Edgewood North	EWN C	5.0	23.0	**28.0**
	EWN T	4.5	22.0	**26.5**
Edgewood South	EWS C	5.0	25.0	**30.0**
	EWS T	4.5	25.0	**29.5**
	Reference	5.0	25.0	**30.0**
Edgewood Total		**24.0**	**120.0**	**144.0**
Mosquito Creek	Drawdown Zone	7.0	35.0	**42.0**
	Reference	7.0	34.0	**41.0**
Mosquito Creek Total		**14.0**	**69.0**	**83.0**
Total (all reaches and treatments)		**91.5**	**467.0**	**558.5**

Malaise and pitfall traps were operational for a total of 13,087.6 hours in all reaches and treatment combinations in 2013; malaise traps were operational for 2,133.8 hours, pitfalls for 10,953.8 hours (Figure 5-4). As in previous years, not all combinations of reach and treatment were sampled (Figure 5-4). Upland reference sites were not sampled at East Arrow Park and Edgewood North because of access issues and revegetation prescriptions were not applied to either Mosquito Creek or Beaton Arm. In general, a similar level of effort was expended between control, treatment, and reference sites at each reach for both Malaise and pitfall traps.

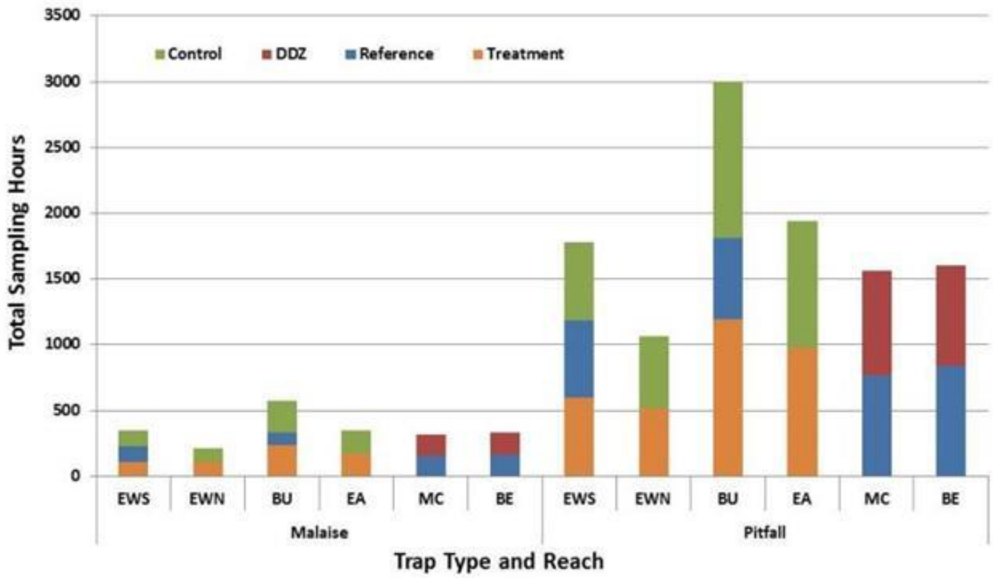

Figure 5-4: Distribution of sampling effort (total hours) in the Arrow Lakes Reservoir in 2013 using Malaise and pitfall traps in the various combinations of reach and treatment. DDZ = drawdown zone. Sites are ordered from south to north in the reservoir: BE = Beaton Arm; BU = Burton Creek; EA = East Arrow Park; EWN = Edgewood North; EWS = Edgewood South; MC = Mosquito Creek

5.2.3 Arthropods – Taxa per Reach and Treatment

The numbers of arthropod taxa (order, family, or species) captured in Malaise traps and pitfall traps were used to characterize the arthropod taxa at each combination of reach and treatment sampled in 2013 (Figure 5-5). Pitfall traps almost always captured more taxa[5] than did Malaise traps, although this was not true for all combinations of reach and treatment. Given that malaise and pitfall traps target taxa with different life histories (flying versus ground-dwelling), the use of both types of traps to characterize the arthropod fauna at each reach and treatment continues to be justified and necessary.

The reference site of Mosquito Creek and control site of Edgewood South were the most diverse with 117 taxa followed by the control site at Burton Creek (*n* = 111 taxa; Figure 5-5). The total number of taxa per reach and treatment was higher than in 2011 (see Figure 5-5 in Hawkes et al. 2012), which is likely due to a higher-level of identification in 2013. We had expected that as the revegetation prescriptions matured the number of taxa would increase (or that biomass would increase) and our results may be a function of that, or due to natural variability.

[5] Identification to family varied between specimens caught in Malaise and pitfall traps. Two taxonomic experts provided identifications of spiders and grasshoppers, both of which were trapped primarily in pitfall traps. Because of this the number of taxa associated with the pitfall trap data is skewed upwards.

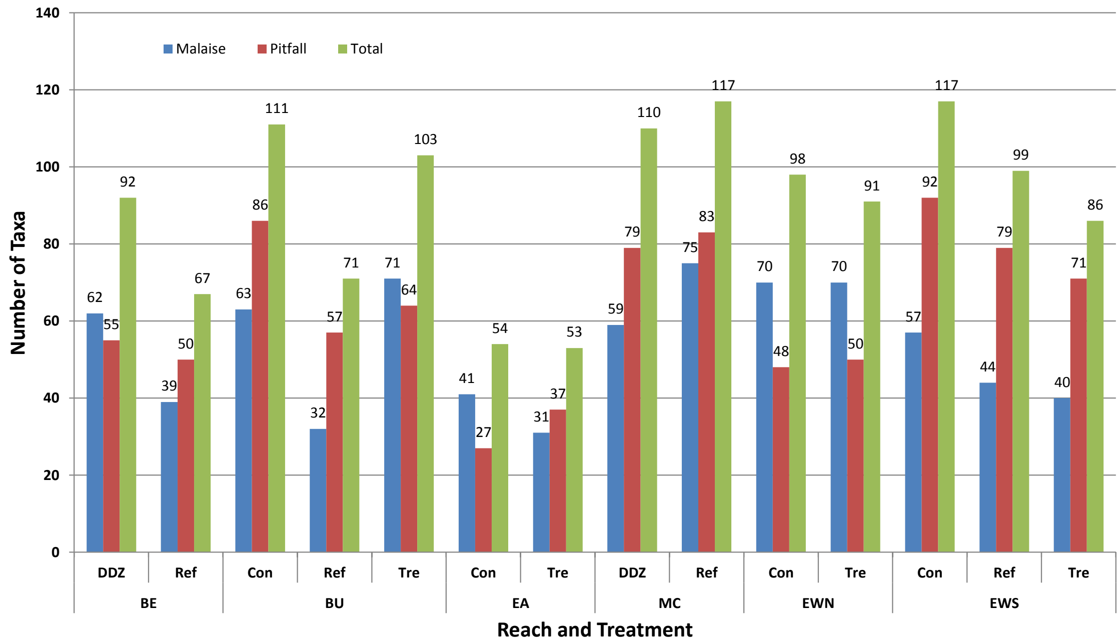

Figure 5-5: Number of taxa (orders / families) captured in malaise and pitfall traps by reach and treatment in the Arrow Lakes Reservoir (2013 data only). DDZ = drawdown zone; Ref: reference site; Con: control site; Tre: treatment site; BE: Beaton Arm; BU: Burton Creek; EA: East Arrow Park; MC: Mosquito Creek EWN: Edgewood North; EWS: Edgewood South

5.2.3.1 Species richness and relative abundance

To assess the relative abundance and species richness of arthropods at the various reaches and treatments sampled in 2013 we assessed data from Malaise and pitfall traps separately for each reach and treatment. For malaise traps, the standardized abundance (the number caught per 10 hour period) of arthropods sampled at each reach was different, but for most combinations of treatment and reach the difference was not significant. Where large differences were obvious (i.e., control zone of Edgewood South), the difference was explained by a very high abundance of Diptera (Figure 5-6, left). For all other sites where revegetation prescriptions were applied (i.e., Edgewood North, East Arrow Park, and Burton Creek) the relative abundance of flying arthropods was similar between control and treatment areas. In most case, the relative abundance of flying arthropods was higher in the drawdown zone than in the upland reference sites. The lack of difference between control and treatment sites at reaches where revegetation prescriptions were applied suggests that there was no effect of treatment on the relative abundance of flying arthropods or that not enough time has passed for the treatment effect to be observed. Sample size could also be limiting.

The standardized abundance of insects captured by pitfall traps was markedly higher in Beaton Arm than at the other reaches (Figure 5-6, right) and was due to a high abundance of Collembola in the upland reference area (628 individuals per 10hr) and the drawdown zone (127 individuals per 10-hr of sampling). The standardized abundance of insects in the control site of Edgewood South and Burton Creek was higher than in their respective treated areas, and the abundance in the drawdown zone of Mosquito Creek was markedly higher than in its reference zone.

Insect abundance was significantly higher in control areas of Edgewood South (F=12.2, p=0.02) and Burton Creek (F=8.6, p=0.005) compared to treatments, and overall, the relative abundance of insects was greater in control than treatment areas at all reaches (F=8.5, p=0.0007; Figure 5-6, right). The differences in CPUE were statistically significant between control and treatment areas (F=10.4, p= 0.002) and among reaches (F=5.9, p=0.001); interactions were significant (F=2.8, p=0.04), and a series of one-way ANOVA was performed to see where the significant differences lay.

Pooling data from control and treatment areas to assess differences between the drawdown zone and upland reference areas revealed that the average CPUE was not significantly different between these two areas (p> 0.05), but differences were still significant among reaches (F=5.8, p=0.0009), likely because of the higher abundances in Beaton Arm.

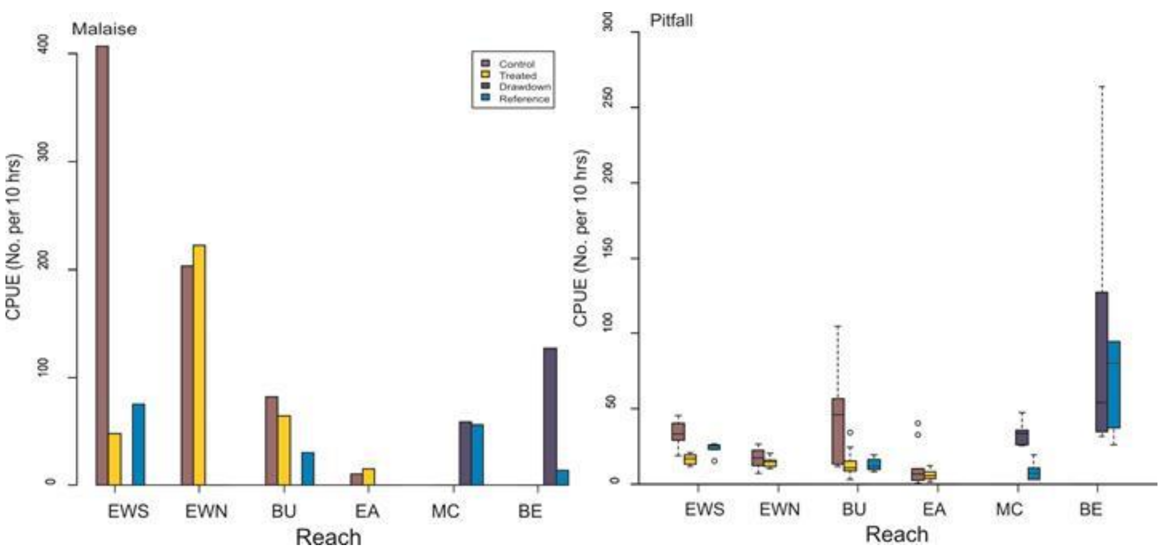

Figure 5-6: Abundance of arthropods (CPUE: catch per unit effort) assessed for malaise traps (left) and pitfall traps (right) for each reach and treatment sampled in 2013 in mid- and lower Arrow Lakes Reservoir. Reaches are ordered from South to North of the reservoir. BE: Beaton Arm; BU: Burton Creek; EA: East Arrow Park; MC: Mosquito Creek EWN: Edgewood North; EWS: Edgewood South. Two outliers at 628 and 127 individuals per 10hr were excluded from the pitfall data at Beaton Arm (pitfalls only)

A total of 193 taxa were documented from all reaches and treatments sampled in and adjacent to the drawdown zone of Arrow Lakes Reservoir in 2013. Of those, 56 taxa were identified to species and 137 taxa were identified to order, families, or species; all taxa were included in the computation of richness, even though there might be some overlap between species and higher taxa. Richness varied among reaches, but not among treatments (Figure 5-7) and similar patterns were observed for both richness and corrected richness. The apparent low richness in East Arrow Park is likely attributable to the lower sampling time at that location. Differences between control and treatment sites were not statistically different.

Differences were significant among reaches (F=21.4, p=0.0001 for richness, and F=12.9, p=0.0001 for corrected richness), but not between the drawdown zone and the upland reference sites (p> 0.05; tested for Beaton Arm, Burton Creek, Edgewood South, and Mosquito Creek). Likewise, species richness did not differ between control and treatment sites (p> 0.05; tested for Burton Creek, East Arrow Park, Edgewood North and South). Species richness did differ significantly among reaches for average richness (F=6.6 p=0.0008) and average corrected richness (F=6.5, p=0.0001).

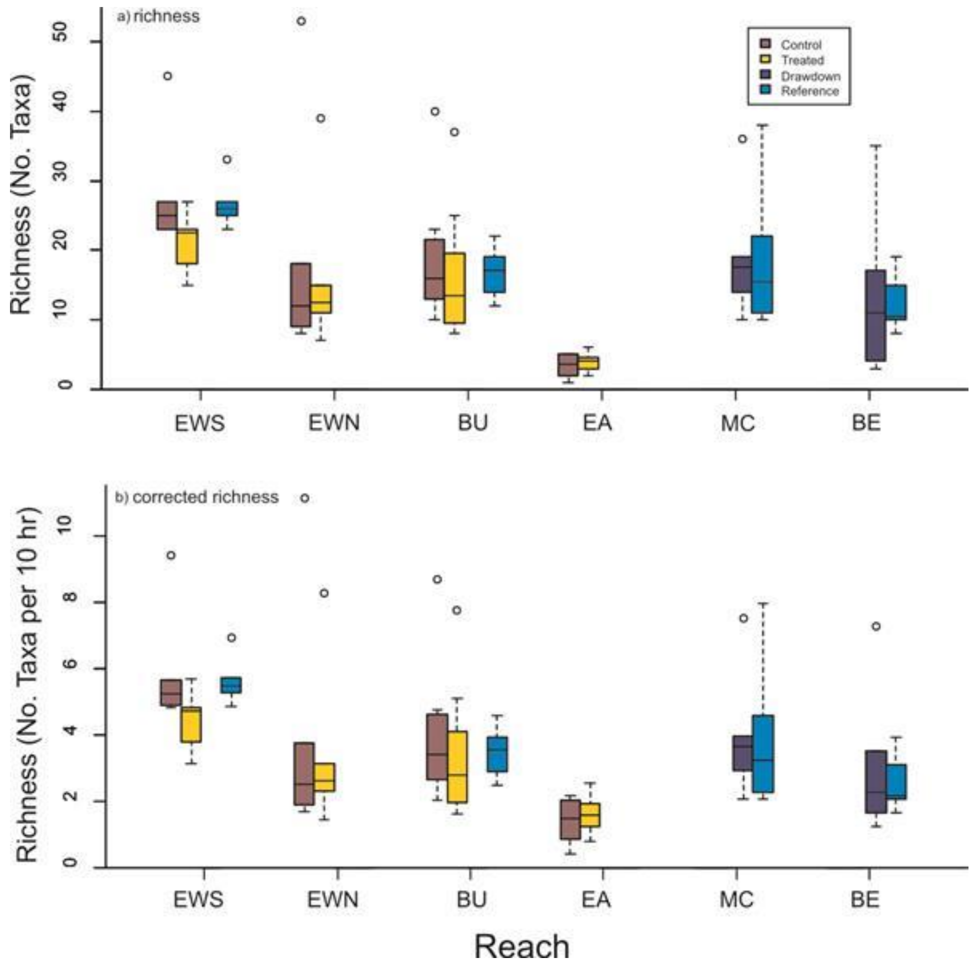

Figure 5-7: Taxonomic richness (number of orders, families, and species) for each reach and treatment sampled in and adjacent to the drawdown zone of mid- and lower arrow Lakes Reservoir in 2013. Reaches ordered from south to north of the reservoir

5.2.3.2 Arthropod Biomass

Arthropod biomass (dry weight, mg/hr) varied by reach, treatment, and year (Figure 5-8). Overall, biomass in 2010 and 2013 was greater than in all other years, but there was considerable between-year variability. In general, arthropod biomass was higher in controls than in treatments.

Total biomass (mg/hr) varied by reach, treatment, and trap type. For Malaise traps, biomass was similar between control and treatments sites except at Edgewood North, where it was higher at the treatment (Figure 5-9a). For reaches where treatments were applied and where upland reference sites were sampled (Edgewood South and Burton Creek), biomass was higher in the drawdown zone sites (both control and treatment) than in reference sites.

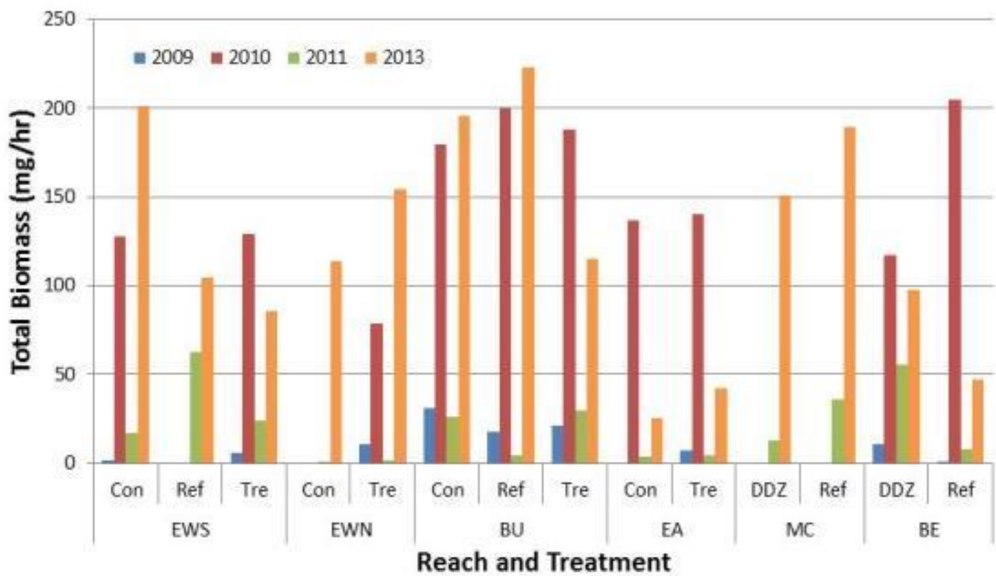

Figure 5-8: **Average arthropod biomass (+ SD) for each reach and treatment sampled in the Arrow Lakes Reservoir 2009, 2010, 2011, and 2013.** BE: Beaton Arm; BU: Burton Creek; MC: Mosquito Creek; EA: East Arrow Park; EWN: Edgewood North; EW: Edgewood South; DDZ: drawdown zone; Ref: reference site; Con: Control site; Tre = treatment site

The biomass of arthropods sampled in pitfall traps was higher in control than treatment sites (F=12.45, p=0.0015; Figure 5-9b), and among reaches (F=19, p= 0.0001); interactions were significant (F=6.97, p=0.007). Biomass was statistically greater at control than treated sites in Edgewood South (F=44.5, p=0.0035), and among reaches for the treatment (F=11.1, p=0.0003), and the control sites (F=37.3, p=0.0001).

When data from the control and treatments area were pooled, the average biomass was significantly higher in the drawdown zone (F=9.4, p=0.001) and significant differences were observed among reaches (F=6.6, p=0.01); interactions were also significant (F=11.3, p=0.0001), which was attributed to the differences between control and treatment sites at Burton Creek (F=33, p=0.0001) and among reaches for the reference areas only (F=232, p=0.0001) (Figure 5-9b).

In all cases, arthropod biomass was higher in controls than in treatments. The differences in biomass were statistically significant between reaches (F=18.9, p=0.0001), but not among controls and treatments (p > 0.05); however, interactions were significant (F=4.8, p=0.004). Biomass in the control areas was higher than the treatments at Edgewood South (F=14.4, p=0.005) and Burton Creek (F=33, p=0.0001), and among reaches for both the treatments (F=10, p=0.0002), and controls (F=46.7, p=0.0001)..

Average biomass was not significantly different between drawdown (control and treatments sites pooled) and upland reference sites (p > 0.05), but differences were still significant among reaches (F=3.7, p=0.02); interactions were again significant (F=6.1, p=0.002). Biomass values were higher in the control at Burton Creek only (F=17.3, p=0.0006), but not among reaches for drawdown or reference zones (p > 0.05).

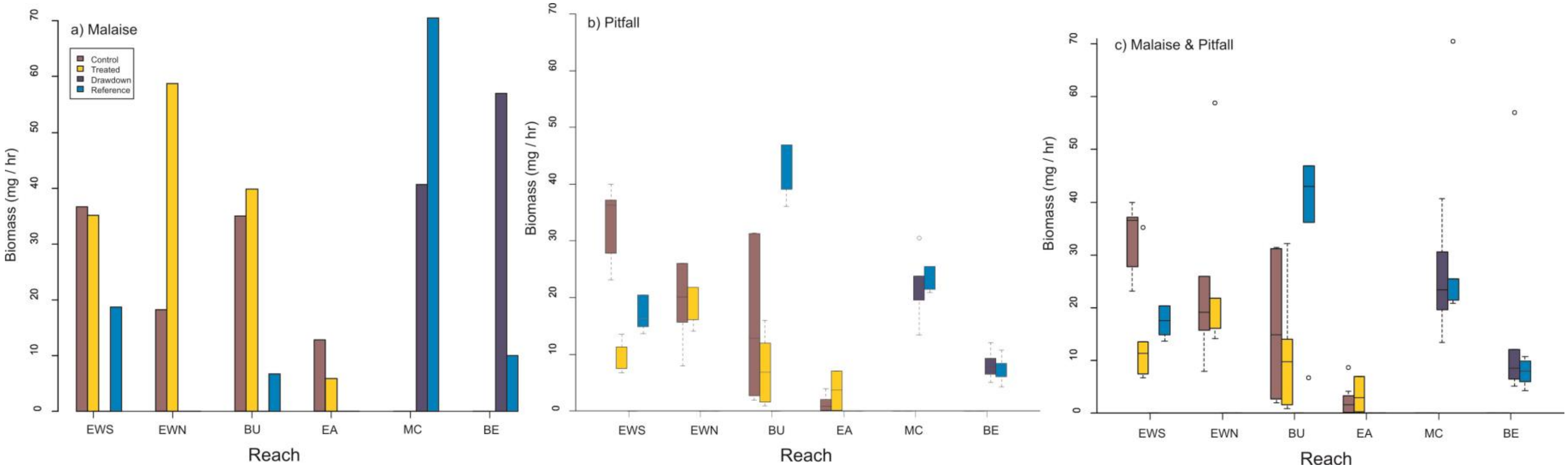

Figure 5-9: **Average arthropod biomass (mg/hr) for each reach and treatment sampled in the Arrow Lakes Reservoir by malaise traps (a), pitfall traps (b), and both (c).** BE: Beaton Arm; BU: Burton Creek; MC: Mosquito Creek; EA: East Arrow Park; EWN: Edgewood North; EW: Edgewood South; DDZ: drawdown zone; Ref: reference site; Con: Control site; Tre = treatment site

Previously, the biomasses of Diptera and Hymenoptera were considered as potential indicators of habitat change in treatment areas of the drawdown zone. Both orders are ubiquitous in their distribution, occurring in almost all reach and treatments in all years sampled (Mosquito Creek was not sampled in 2009 or 2010) (Figure 5-10). The biomass of both orders peaked in 2010 with relatively high number in 2013. Overall, the biomass of both orders was similar in control and treatment zones in all years of study suggesting that either these orders are not suitable indicators or that the treatments applied do not have influence on the productivity of either order.

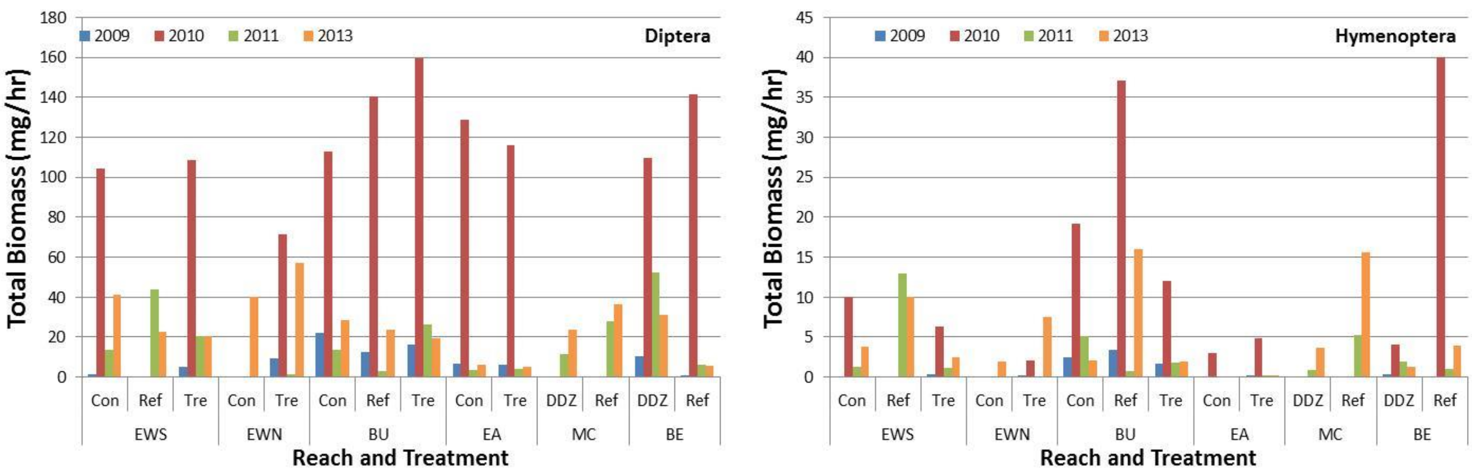

Figure 5-10: Average arthropod biomass (mg/hr) for Diptera (left) and Hymenoptera (right) for each reach and treatment sampled in the Arrow Lakes Reservoir (2009–2013) by malaise traps. BE: Beaton Arm; BU: Burton Creek; MC: Mosquito Creek; EA: East Arrow Park; EWN: Edgewood North; EW: Edgewood South; DDZ: drawdown zone; Ref: reference site; Con: Control site; Tre = treatment site

5.2.3.3 Arthropod community similarity

As indicated in Hawkes et al. (2011), if the application of revegetation prescriptions in the drawdown zone affects the presence and/or abundance of arthropod taxa, community similarity might differ, indicating a potential treatment effect. In 2010 the groupings of sites depended on the coefficient used. With coefficient D14, which gives the same weight to rare and abundant species, the 2010 arthropod community similarity was not reach-specific. Alternatively, when more weight was given to rare species (using coefficient D17), the groupings suggested that rare species were more characteristic of the treatments (control, treated, or reference) than of the reaches. This trend was observed in 2011 and again in 2013 (i.e., no clustering of sites or a clustering of treatment sites; Figure 5-11). The interpretation of community similarities in 2013 continues to suggest that arthropod communities of the drawdown zone (irrespective of treatment) are similar, but different from those in the upland reference sites–a result that is not unexpected.

The data presented Figure 5-11 are from malaise traps only and it appears that the revegetation prescriptions applied in the drawdown zone have not influenced the arthropod communities, at least not in a measureable way, which aligns with data presented in Figure 5-6. Either the prescriptions applied do not influence flying insects or flying insects are not suitable indicators of change. Alternatively, the effect, if any, is masked by other factors such as changing reservoir elevations or environmental conditions. However environmental conditions over the last three years have been similar (Figure 5-1). Given that treatment sites and control sites cluster together, it seems that the influence of the revegetation treatments on flying insects is negligible. This result is the same regardless of whether rare or abundant species are given more weight.

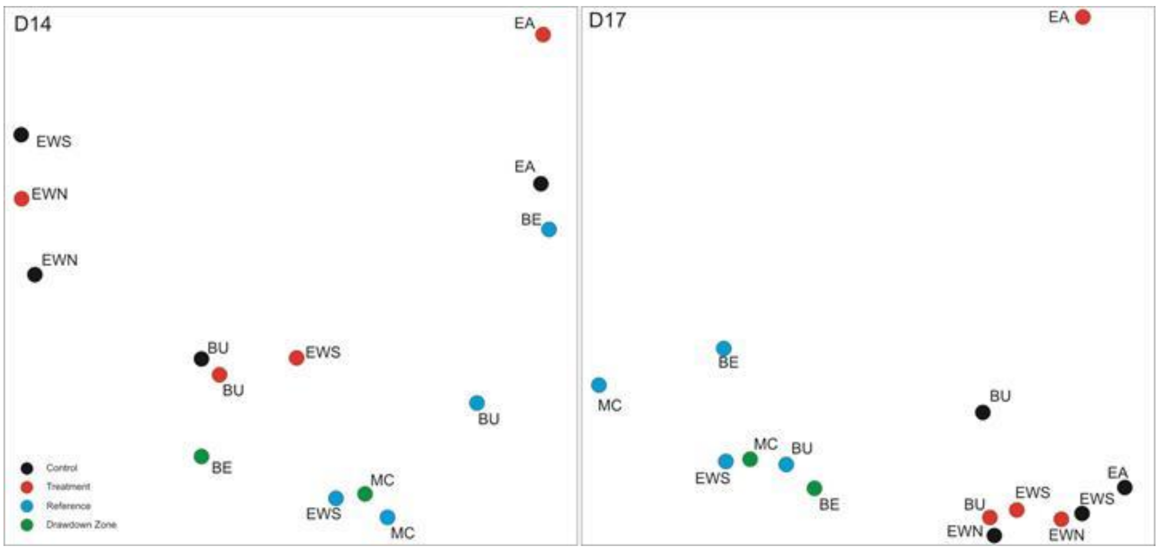

Figure 5-11: Principal Coordinates Analysis ordination diagram showing relationships among treatments and reaches (which include control, treatment, drawdown zone, and reference sites) according to their similarities with respect to flying arthropod communities collected in Malaise traps as computed by the Bray-Curtis distance (D14; same weight to rare and abundant species) and Hellinger-Euclidian distance (D17; more weight to rare species). D14: Axis 1 explains 34% of the similarities, axis 2, 20%. D17: Axis 1 explains 34% of the similarities, axis 2, 21%

Insect community similarity determined from data collected in pitfall traps did not appear to form any specific patterns with respect to the various treatments and there is not apparent effect of revegetation on ground-dwelling insects. Only the insect communities in the drawdown and reference zones in Beaton Arm were different than the rest of the reaches, with the most similar community being that of the control site in Burton Creek (Figure 5-12). Edgewood South control and treatments areas were similar to the treatment area in Burton 01(the live-stake treatment) and the control zone in Burton 02 (plug-seedling treatment), while the treatment areas in East Arrow Park (all plug-seedling) and Burton 02 were also very similar, and similar to the upland reference zone of Mosquito Creek. Results were slightly different with D17; the communities in Beaton Arm were not so different from the others (Figure 5-12, right). The control area in Burton 02 was different from the other communities. In general, this suggests that the treatments applied to the drawdown zone of mid- and lower Arrow Lakes Reservoir have not yet influenced the insects using those areas. This may be a function of habitat availability (which is affected by reservoir operations) the relatively short time that has passed since revegetation occurred.

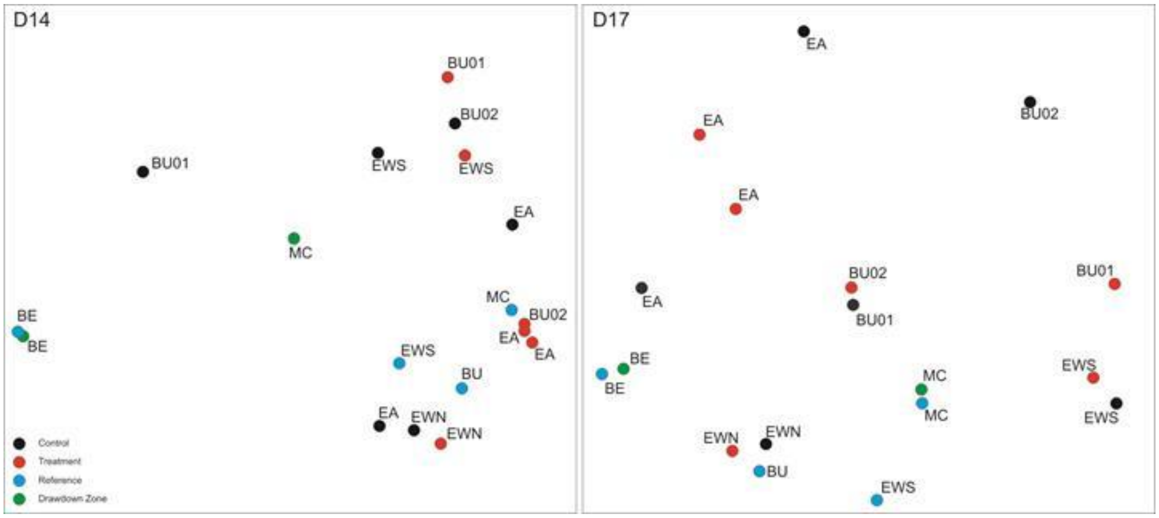

Figure 5-12: Principal Coordinates Analysis ordination diagram showing relationships among treatments and reaches according to their similarities with respect to ground-based arthropod communities as computed by the Bray-Curtis distance (D14; same weight to rare and abundant species) and Hellinger-Euclidian distance (D17; more weight to rare species). D14: Axis 1 explains 32% of the similarities, axis 2, 17%. D17: Axis 1 explains 30% of the similarities, axis 2, 19%

5.2.3.4 Arthropod species assemblages

Most arthropod taxa in the mid-and lower Arrow Lakes Reservoir were similar (W = 0.092, p < 0.001). Partitioning arthropod taxa into two groups was the optimal solution according to K-means, and the two groups segregated well along the X-axis of the PCA diagram (Figure 5-13). Taxa from both groups were significantly concordant in their association with specific treatments and reaches (group 1: W = 0.14, p < 0.001; group 2: W = 0.13, p < 0.001). After correction for multiple testing, one family was still significantly concordant in group 1 at α = 0.05 (Coccinellidae), and one more at α=0.1 (Acrididae) and two families (Amaurobiidae and Vespidae) were concordant with each other in group 2.

The two groups of taxa can be linked to different treatments and/or reaches, suggesting a drawdown zone or upland habitat association (Figure 5-13). Taxa in group 1 were associated with the control (drawdown sites included) and treatment sites in the drawdown zone for all reaches in lower Arrow Lakes Reservoir, and with the drawdown zone of Beaton Arm. Taxa in group 2 were associated with the upland (i.e., reference sites) of Burton Creek, Edgewood South, Beaton Arm, and the drawdown zone of Mosquito Creek. The groups associated with the 2013 data are similar to those associated with the 2010 and 2011 data (Hawkes et al. 2011a).

Focusing future analyses on those taxa in group 1 (the drawdown zone group) may help identify treatment effects associated with the application of the revegetation prescriptions. For example, if the live stake prescription increases the amount of treed habitat in the drawdown zone, then the taxa associated with that treatment should start to resemble that of the upland grouping shown in Figure 5-13.

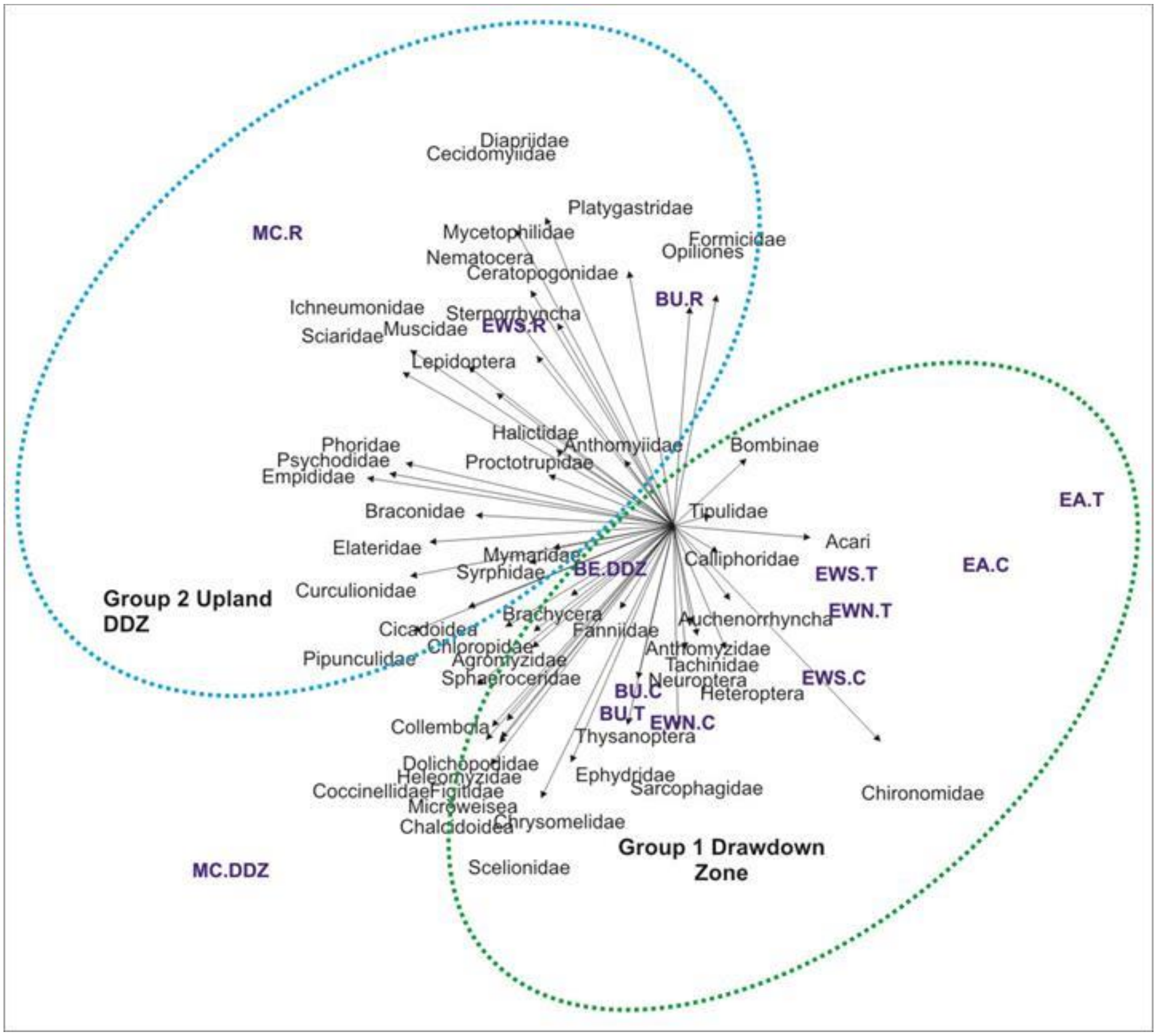

Figure 5-13: Principal Components Analysis ordination diagram with superposition of the partition results by K‐means. Groupings of arthropod taxa are shown by coloured ellipses. Black vectors represent species. Axis 1 = 27 per cent and axis 2 = 22 per cent of the variation in the multi-dimensional data set. Group 1 (blue ellipse) represents the drawdown zone, and group 2 (green ellipse) represents the upland of Burton Creek. BU.TRE: treatment sites of Burton, BU.CON: control sites of Burton, BU.REF: reference sites of Burton; BE.DDZ: control sites of Beaton, BE.REF: reference sites of Beaton; EA.TRE: treatment sites of East Arrow Park, EA.CON: control sites of East Arrow Park, EA.REF: reference sites of East Arrow Park; EN.TRE: treatment sites of Edgewood North, EN.CON: control sites of Edgewood North, EN.REF: reference sites of Edgewood North; MC.DDZ: control sites of Mosquito Creek, MC.REF: Reference sites of Mosquito Creek; ES.TRE: treatment sites of Edgewood South, ES.CON: Control sites of Edgewood South, ES.REF: reference sites of Edgewood South

5.2.4 Terrestrial Arthropods – Indicator Species

In 2010 and 2011 we suggested that spiders and beetles may be suitable indicators of habitat changes associated with the application of revegetation prescriptions in the drawdown zone of mid- and lower Arrow Lakes Reservoir. In 2013 we re-evaluated the utility of both spiders and beetles as indicators.

5.2.4.1 Araneae (Spiders)

In 2010 and 2011 we collected spiders to determine if they were a suitable group for assessing habitat change. They were collected again in 2013 to increase our understanding of the distribution of spiders in and adjacent to the drawdown zone and relative to revegetation treatments. One-hundred and ten species of spiders from 20 families were identified in 2013 (vs. 75 species of 18 families in 2011 and 87 species of 17 families in 2010; Figure 5-14). Linyphiidae (sheet-web and dwarf sheet spiders) species dominated the 2010 and 2011 samples but in 2013 half as many species were identified in this family. An overall trend of species diversity decline was observed and was most obvious with Linyphiidae (n=17; 2013, n=24; 2011, n=35; 2010; Figure 5-14). As in previous years Lycosidae (wolf spiders; n = 11 species) had the second highest species diversity of spider families identified from the collection at all reaches and treatments.

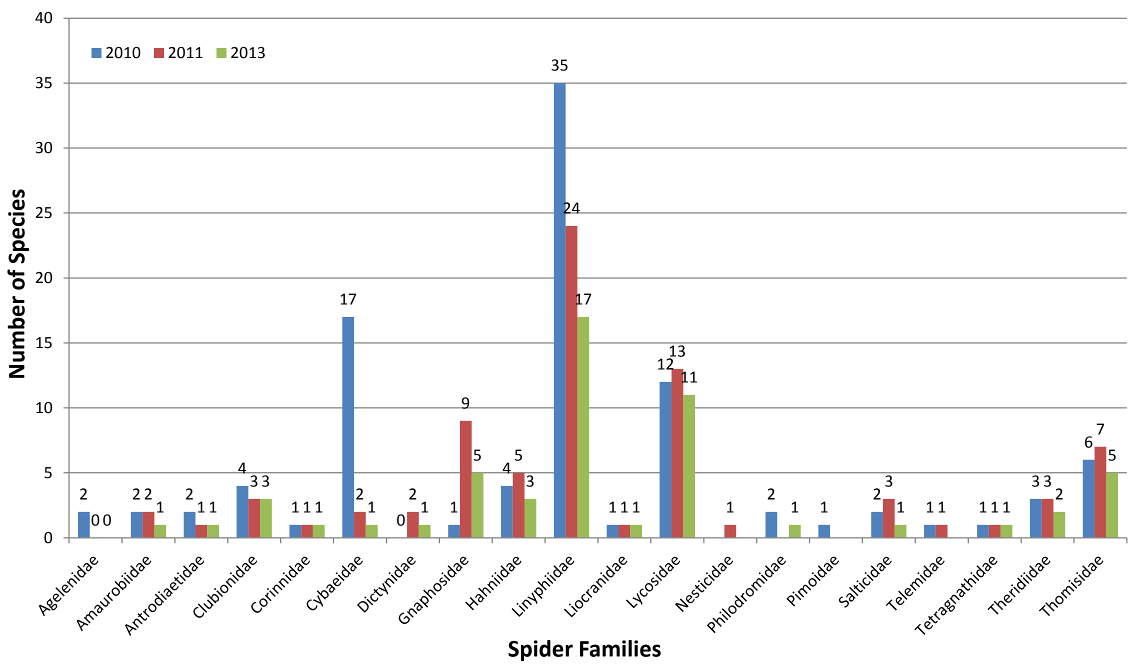

Figure 5-14: Number of spider species in each family documented at sites in the mid- and lower Arrow Lakes Reservoir in 2010, 2011 and 2013. Data from all reaches and treatments pooled.

The number of spider families and species varied between reach and treatment, with most species and families occurring in the reference sites of Edgewood South (Figure 5-15). Given the variation in the number of species and families and that the number of families and/or species did not differ much between the control and treatment sites and even drawdown zone and upland reference sites, using species richness of all spiders as an indicator is not supported by the data. A data set based on additional years of data may help support or refute this assessment.

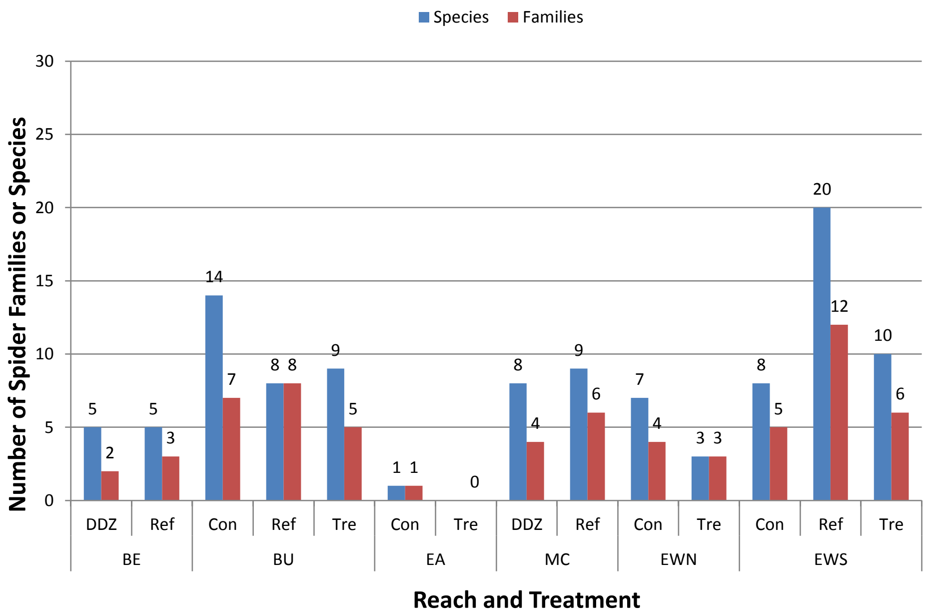

Figure 5-15: Spider families and species documented per reach and treatment in the Arrow Lakes Reservoir in 2013. EWS = Edgewood South; EWN = Edgewood North; BU = Burton Creek; EA = East Arrow Park; MC = Mosquito Creek; BE = Beaton Arm. DDZ = drawdown zone; Ref = Reference; Tre = Treatment

To further assess the applicability of spiders as indicators of habitat change we continued to assess the distribution of unique species of Linyphiidae, Lycosidae and Thomisidae (three of the dominant families in 2010, 2011 and 2013) to determine if certain species occurred only in the drawdown zone or reference sites (Figure 5-16). Thomisidae occurred in low numbers and not at all sites. At Mosquito Creek and Edgewood South Thomisidae species were found at reference sites and at Burton one species was found at both treatment and reference sites. A Linyphiidae species, *Tenuiphantes zelatus* occurred only in reference areas and species from Lycosidae, *Pirata piraticus*, *Pardosa groenlandica* and *Pardosa fuscula* were collected only in drawdown zone (control and treatment).

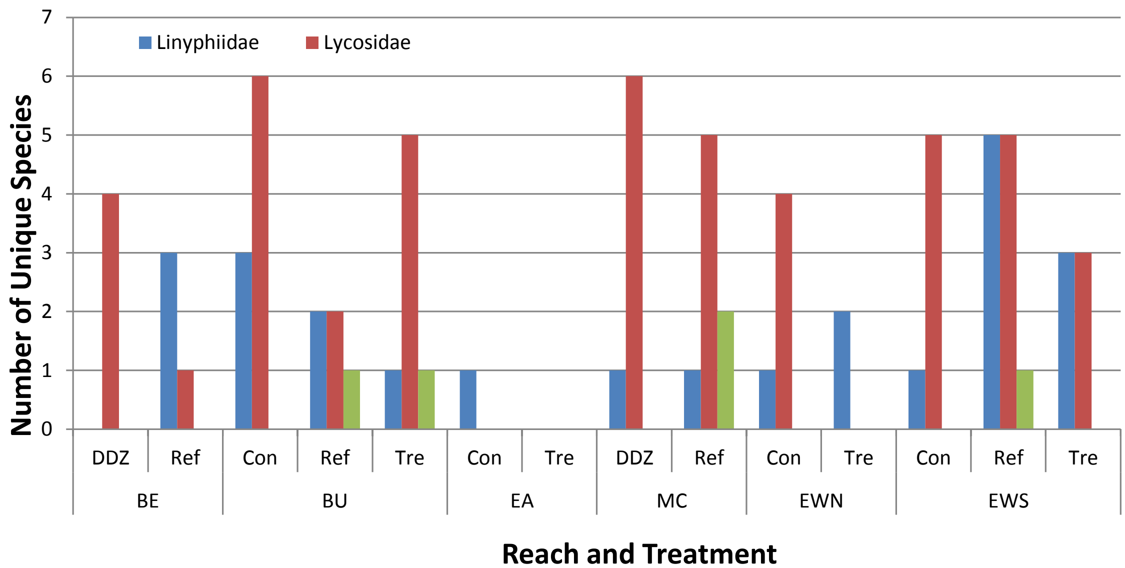

Figure 5-16: Number of species of the families Linyphiidae, Lycosidae, and Thomisidae associated with each reach and treatment sampled in mid- and lower Arrow Lakes Reservoir in 2013. EWS = Edgewood South; EWN = Edgewood North; BU = Burton Creek; EA = East Arrow Park; MC = Mosquito Creek; BE = Beaton Arm. DDZ = drawdown zone; Ref = Reference; Tre = Treatment

Based on these results and on the existing literature (see Discussion), the ability to use spiders to assess changes in habitat quality associated with revegetation of the drawdown zone continues to be high. In particular, species of sheet-web and dwarf sheet spiders (Linyphiidae) and wolf spiders (Lycosidae) have shown opposite responses to increasing vegetation cover, suggesting that the species of these two groups could serve as surrogates for all spiders. The data collected in 2011 and 2013 support the use of certain species from these families of spiders as potential indicators of habitat change.

5.2.4.2 Coleoptera (Beetles)

In 2013 we considered the suitability of ground beetles (Carabidae) and rove beetles (Staphylinidae) as indicators of habitat change associated with the revegetation of the drawdown zone. With an additional year of data collection we may have enough data to further assess the utility of beetles (specifically Carabidae) as a potential indicator of habitat change. These families were ubiquitous in their distribution, occurring at all treatments and reaches sampled (Figure 5-17). There is a distinction between the relative abundance of beetles in the drawdown zone (control and treatment) compared to the upland reference sites, but not between all control and treatments areas in the drawdown zone. At the Edgewood sites, the relative abundance of beetles is higher in the controls than in the treatments and it is not clear why these differences exist.

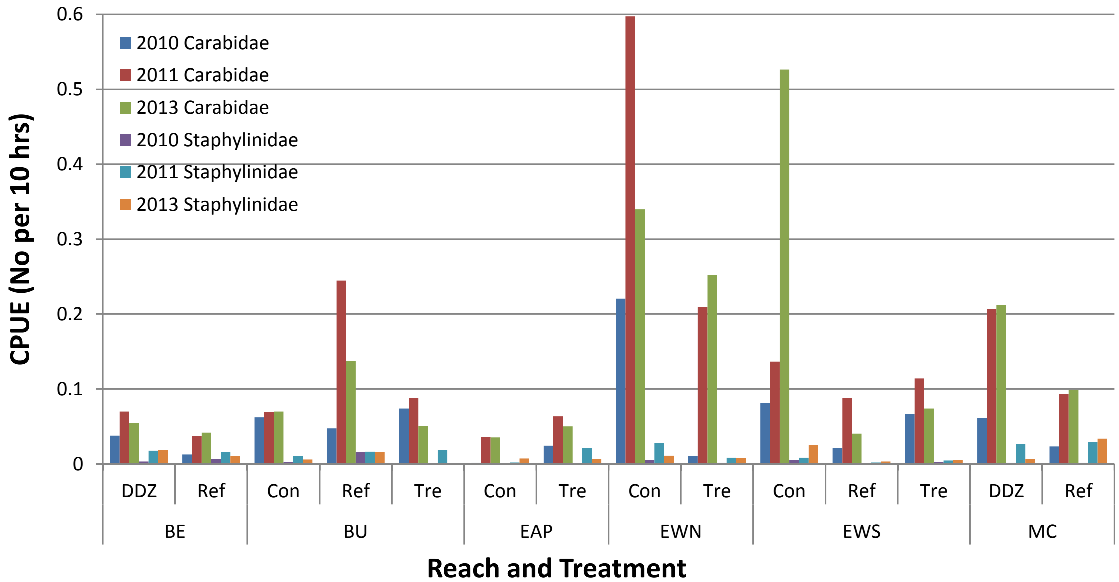

Figure 5-17: Catch per unit effort of Carabidae, Staphylinidae at each reach and treatment sampled in and adjacent to the drawdown zone of mid- and lower Arrow Lakes Reservoir in 2010, 2011 and 2013. DDZ: drawdown zone; Ref: reference site; Con: control site; Tre: treatment site; BE: Beaton Arm; BU: Burton Creek; EA: East Arrow Park; MC: Mosquito Creek; EWN: Edgewood North; EWS: Edgewood South

5.2.5 Songbirds - Overview

Songbirds were surveyed between May 19 and June 26, 2013. A total of 123 variable radius point counts were sampled in 2013 (vs. 117 in 2011, 106 in 2010, and 107 in 2009; see Appendix 10-C for maps depicting the distribution of songbirds point count locations). Each point count was visited two or three times (Table 5-3) and visits to each point count were generally separated by 12 to 19 days to capture within-year variability in species presence and detections. Survey effort varied by reach, and the number of point counts established per reach was a function of the area available for sampling at each reach. Some point counts were not available for sampling later in the survey period due to inundation from rising water levels. As with other years, the highest number of point counts sampled in 2013 was in East Arrow Park, followed by Burton Creek. Revegetation prescriptions were not applied at either Mosquito Creek or Beaton Arm; therefore, point counts were established only in drawdown and reference (upland) habitats.

Table 5-3: Number of point counts sampled per reach, and type of treatment in 2013. Reaches are ordered from south to north in the Arrow Lakes Reservoir. DDZ: drawdown zone; BE: Beaton Arm; BU: Burton Creek; EA: East Arrow Park; EN: Edgewood North; ES: Edgewood South; LI = Lower Inonoaklin; MC: Mosquito Creek

Reach	Control	DDZ	Reference	Treatment	Total
BE		7	9		16
BU	7	4	9	7	27
EA	8	2	11	8	29
EN	2	2	4	4	12
ES	3		6	3	12
LI				9	9
MC		9	9		18
Total	**20**	**24**	**48**	**31**	**123**

A total of 2,837 observations were made of 102 species in 2013 (Table 5-4). As one observation might consist of multiple individuals, the actual number of total individuals is much higher (4,203). While the number of point counts surveyed was higher in 2013 than in previous years, the total number of visits to point counts was lower, owing to the inaccessibility of many stations during the middle and final survey rounds due to reservoir levels. However, the difference in the total number of species, observations, and individuals is likely a reflection of annual variation, rather than any change in survey effort (with the exception of 2009 which had low overall survey effort and low numbers of species and detections).

Table 5-4: Total number of point count stations, visits, and bird detections recorded during four years of sampling under CLBMON-11B1

Year	Total PC Stations	Total PC Visits	Total Species	Total Observations	Total Individuals
2013	123	294	102	2,837	4,203
2011	117	342	121	3,297	5,021
2010	107	412	116	2,046	3,793
2009	106	179	79	791	1,013

Songbirds were the most frequently encountered group, with 59 species and four additional species of swift and hummingbird were observed (Table 5-5). A comparison of the total number of species per group and reach between the years is provided in Appendix 10-D. The number of songbird species documented per reach varied from 63 at East Arrow Park to 46 at Edgewood North, which is consistent with data collected from 2009 to 2011.

Table 5-5: Total number of species observed and detections per bird group recorded in and adjacent to the drawdown zone in 2011. BE: Beaton Arm; BU: Burton Creek; EA: East Arrow Park; EN: Edgewood North; ES: Edgewood South; MC: Mosquito Creek. Spp: Species; Est: Estimated number of individuals. Blanks indicate no observations

2013	BE		BU		EA		EN		ES		LI		MC		Total	
Bird Group	**Spp**	**Est**	**Spp**	**Est**	**Spp**	**Est**	**Spp**	**Est**	**Spp**	**Est**	**Spp**	**Est**	**Spp**	**Est**	**Spp**	**Est**
Hawks, Eagles, Falcons and Allies	2	7	4	27	4	15	2	6	4	19	1	1	3	12	6	87
Kingfishers and Allies	1	2	1	2					1	2	1	1	1	1	1	8
Nightjars and Allies			1	1											1	1
Pheasants, Grouse, Quail and Allies	1	4	1	6									1	2	1	12
Pigeons and Doves					1	1	1	2	1	1					1	4
Shorebirds, Gulls, Auks and Allies	2	11	2	28	4	17	2	27	2	12	3	32	3	19	6	146
Songbirds	36	341	37	539	43	666	29	186	36	290	33	234	38	377	59	2633
Swifts and Hummingbirds	2	21	3	39	1	5	2	5	2	8			2	3	4	81
Waterfowl	4	257	4	220	6	405	6	59	4	22	11	66	4	41	16	1070
Loons and Grebes	2	3	1	12	1	10	2	4	2	32	1	3			2	64
Woodpckers and Allies	4	24	2	6	3	15	2	5	5	15	2	4	5	28	5	97
Total Species and Detections	54	670	56	880	63	1134	46	294	57	401	52	341	57	483	102	4203

5.2.6 Songbirds, Swifts, Swallows, and Hummingbirds

The following analyses were completed only for songbirds, and swifts, swallows, and hummingbirds to (1) provide an overview of the avifauna documented from each reach and treatment sampled in 2013; (2) highlight differences in species richness, relative abundance, community similarity, and songbird assemblages in and adjacent to the drawdown zone of Arrow Lakes Reservoir; (3) compare data collected between 2009 and 2011 to those collected in 2013; and (4) continue to assess species of songbirds (i.e., swallows) that may be suitable focal species for monitoring the effectiveness of revegetation prescriptions applied in the drawdown zone of Arrow Lakes Reservoir. Maps depicting the location and distribution of songbird point count stations for each reach and treatment sampled in 2013 are provided in Section 10.3.

A total of 2,714 individuals of 63 species of songbirds, swifts, swallows and hummingbirds were made in 2013. Applying the selection criteria outlined in Hawkes et al. (2010) to the bird data collected in 2013 resulted in the following datasets:

1. Birds within 75 m of the point count centre: 1,391 individuals of 57 species (*n* = 53 songbird species and four species of swifts and hummingbirds)
2. Birds documented within 30 m of the point count centre: 433 individuals of 47 species (*n* = 43 songbird species and four species of swifts and hummingbirds)

5.2.6.1 Species richness and relative abundance – annual variation

To provide an indication of annual variation in songbird communities, differences in species richness by reach and treatment (Figure 5-18 and Figure 5-19) between years were assessed based on all songbirds documented from within 75 m of the point count centre. Species richness was corrected for sampling effort by dividing the total number of species by the total number of point counts sampled in each combination of treatment and reach.

Overall differences in species richness were significant among reaches and years both without (F=5.5, p=0.001; and F=9.4, p=0.0001), and with correction (F=10.1, p=0.0001; and F=14.9, p=0.0001). Richness was, however, not significantly different between 2011 and 2013 in Lower Inonoaklin (p> 0.05). Richness increased slightly over time in Edgewood South, and was on average minimal in Lower Inonoaklin (Figure 5-18a). When richness was corrected for sampling effort, it appeared higher in 2009 in Edgewood North compared to the following years (Figure 5-18b).

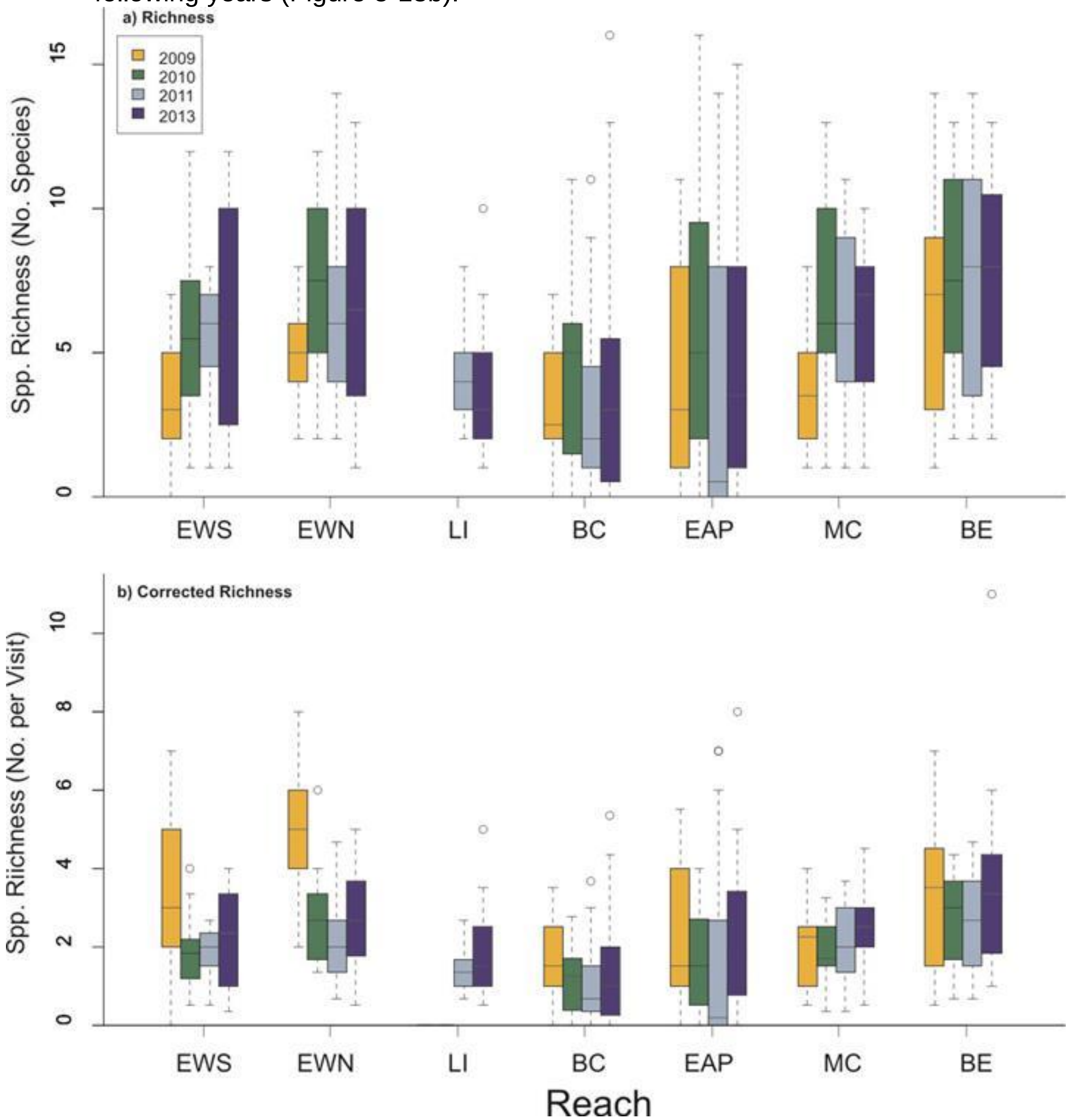

Figure 5-18: Variation in species richness of songbirds a) number of species per point count, and b) corrected for sampling effort (number of species per point count per visit), among reaches and years. Reaches were ordered from South to North of the reservoir

Species richness was higher in the reference sites compared to control, treatment, and drawdown zone areas for both uncorrected (F=88.2, p=0.0001) and corrected richness (F=52, p=0.0001) (Figure 5-19). Differences among years were also significant for the corrected richness (F=3.8. p=0.01).

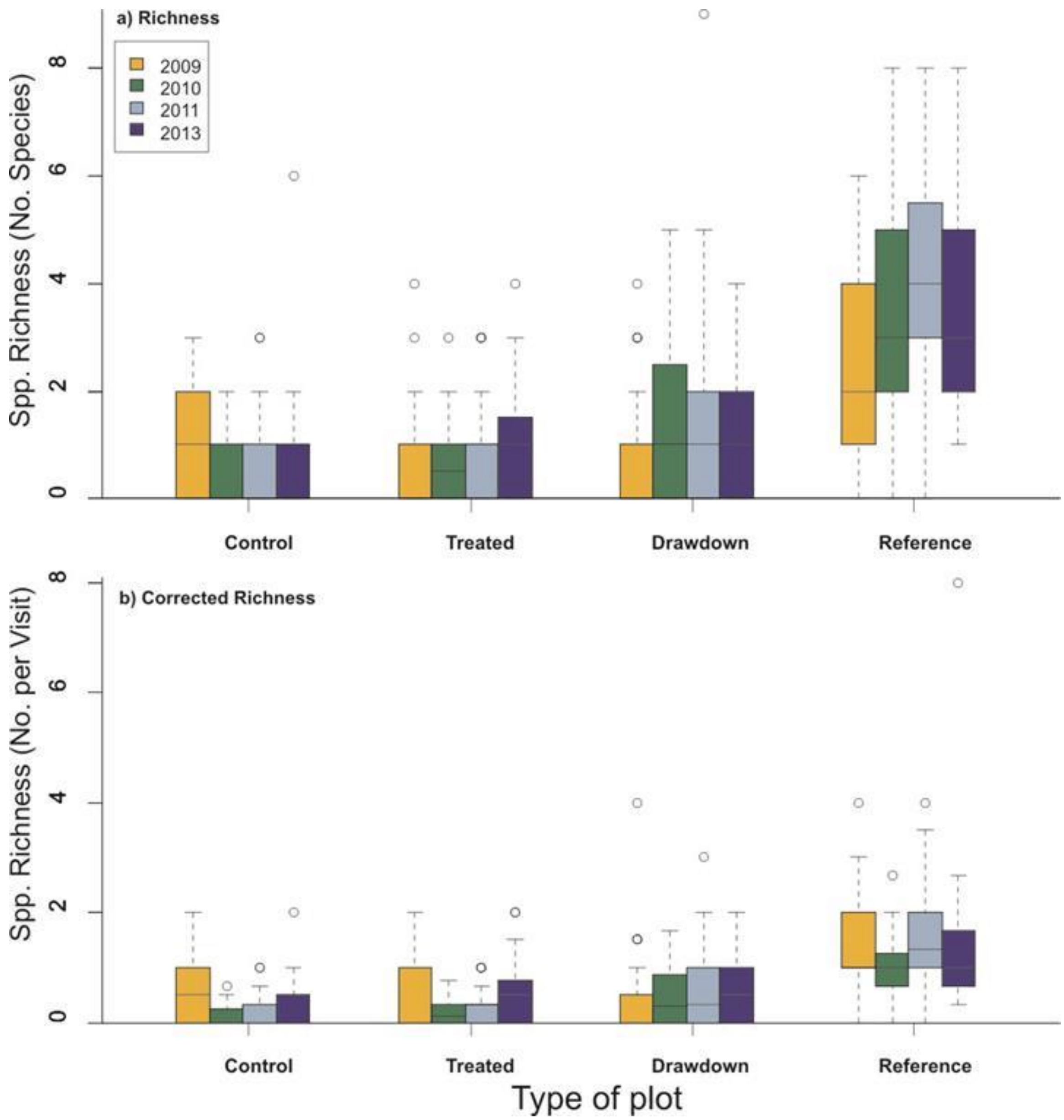

Figure 5-19. Variation in species richness, a) number of species per point count, and b) corrected for sampling effort (number of species per point count per visit), among types of plot and years

The relative abundance of songbirds sampled varied between 0 and 10 counts per visit (Figure 5-20). No clear differences over time are apparent; however there is a slight decline in relative abundance over time in Edgewood North. The two-way ANOVA showed differences in average abundance were significant among reach and year ($F = 3.1$, $p = 0.025$ and $F = 8.4$, $p < 0.0001$), likely due to the few outliers above 15 counts per visit**.** The differences in relative abundance between control and treatment sites were not significant between years at Lower Inonoaklin (p> 0.05)

One outlier with a relative abundance of 71 birds per visit corresponds to a count of ~200 swallows made in May 2010 at a point count at Edgewood North (EN-JG-03) and was removed from the analysis. Figure 5-20 shows the variation in relative abundance among reaches and years without the outlier.

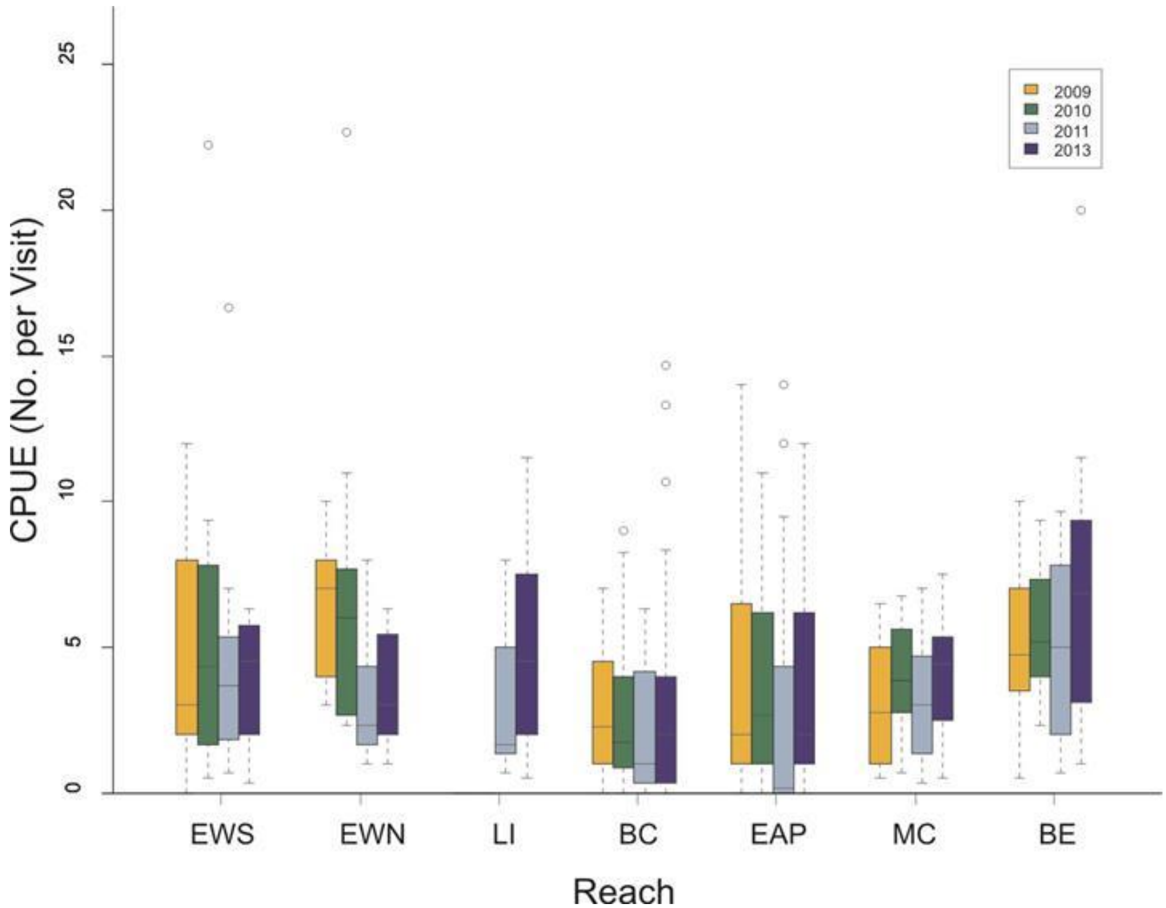

Figure 5-20. Variation in relative abundance (counts of birds per visit) of songbirds among reaches over time. Reaches were ordered from South to North of the reservoir. An outlier of 71 birds per visit in 2010 at the point count EN-JG-03 was excluded from the figure

The relative abundances of songbirds in the reference plots were significantly higher than in the drawdown zone plots (Figure 5-21; $F=22.7$, $p=0.0001$). The differences in relative abundance between types of plots among years were not significant ($p> 0.05$).

The continued difference in relative abundance and species richness between drawdown zone and upland reference sites is not surprising given the difference in habitat structure and composition. The variation within the drawdown zone was also expected owing to the natural annual variation typically associated with the presence and abundance of songbirds in a given area.

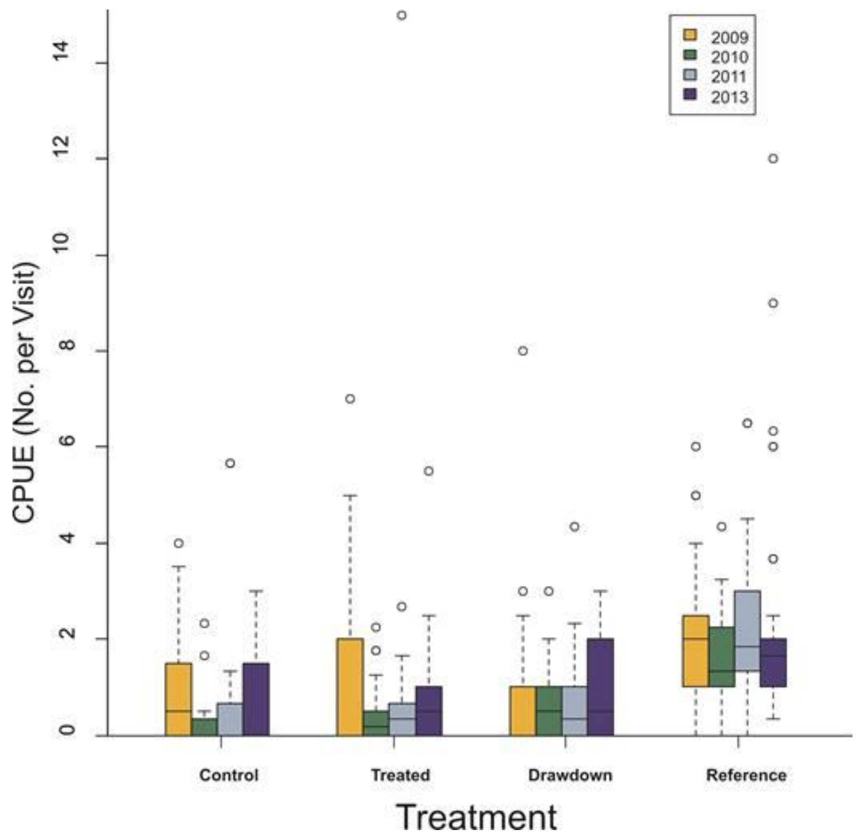

Figure 5-21. Variation in relative abundance (counts per visit) of songbirds among types of plots over time

There was a high variation in diversity of songbird communities both within and among reaches, especially in Burton Creek and East Arrow Park (Figure 5-22). Diversity decreased over time in Lower Inonoaklin, but increased after 2009 in Mosquito Creek. Differences in average diversity among reaches (Lower Inonoaklin treated separately since sampled only in 2011 and 2013) were not significant (p> 0.05), but they were among years (F=12, p=0.0001). Control and treatment plots had several point counts with a diversity of zero (corresponding to point counts with a richness of 1 species per visit or less); diversity of songbirds was markedly higher in drawdown and reference plots (Figure 5-22). Diversity seemed to decline slightly in the reference plots in 2013. Differences among plot type was significant (F=91.1, p=0.0001), but not among years (p> 0.05). The interaction was almost significant (F=1.9, p=0.053), and a series of one-way ANOVAs was performed to assess for which type of plots the differences in diversity among years was significant. The only significant result was for reference plots (F=3.4, p=0.02).

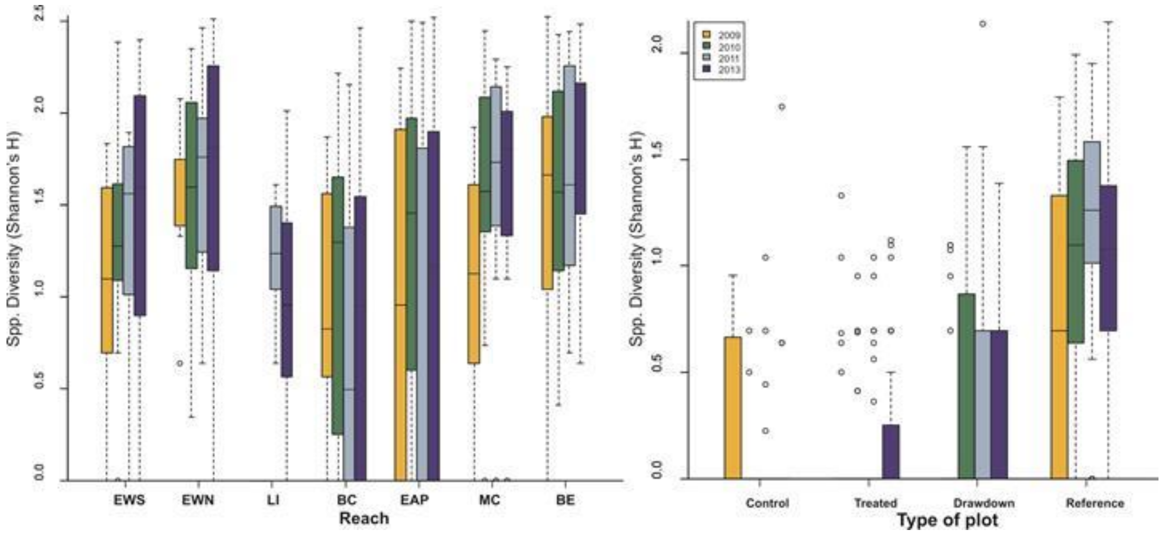

Figure 5-22. Variation in species diversity (Shannon H) of songbirds among reaches (left) and treatments (right) over time. Reaches were ordered from South to North of the reservoir

Evenness was generally very high in most reaches, except for Burton Creek and East Arrow Lakes, where the within-reach variation was large. Evenness declined between 2011 and 2013 in Lower Inonoaklin, but was fairly constant in the other reaches. Differences in evenness were significant among years (F=10.8, p=0.0001), but not among reaches (all reaches but Lower Inonoaklin tested together; p> 0.05). Evenness was, however, significantly different between years in Lower Inonoaklin (F=3.6, p=0.03). Evenness varied greatly within type of plots, especially for the drawdown plots, and in 2009 for control and reference plots, likely because of the presence of many zeroes (richness of 1 species/visit or less;. Evenness was markedly higher in the reference plots in 2010, 2011, and 2013. Differences in average evenness were significant among types of plots (F=62.9, p=0.0001), but not among years (p> 0.05).

5.2.6.2 Species richness and relative abundance 2013 – treatments

The relationship between revegetation prescriptions and the relative abundance (detection rate) of songbirds is not yet clear and more data are required to investigate this. However, it appears that the pattern of higher relative abundance in treatment vs. control sites observed in 2010 and 2011 is persisting at specific sites, which could be a reflection of improved wildlife habitat quality in the drawdown zone resulting from the application of revegetation prescriptions.

Total species richness of songbirds detected within 30 m of the point count centre in 2013 was markedly higher in the reference plots in all reaches where it was sampled, even when richness was corrected for sampling effort (Figure 5-23). However, differences in richness among control and treatment plots and among reaches were not significant (p> 0.05).

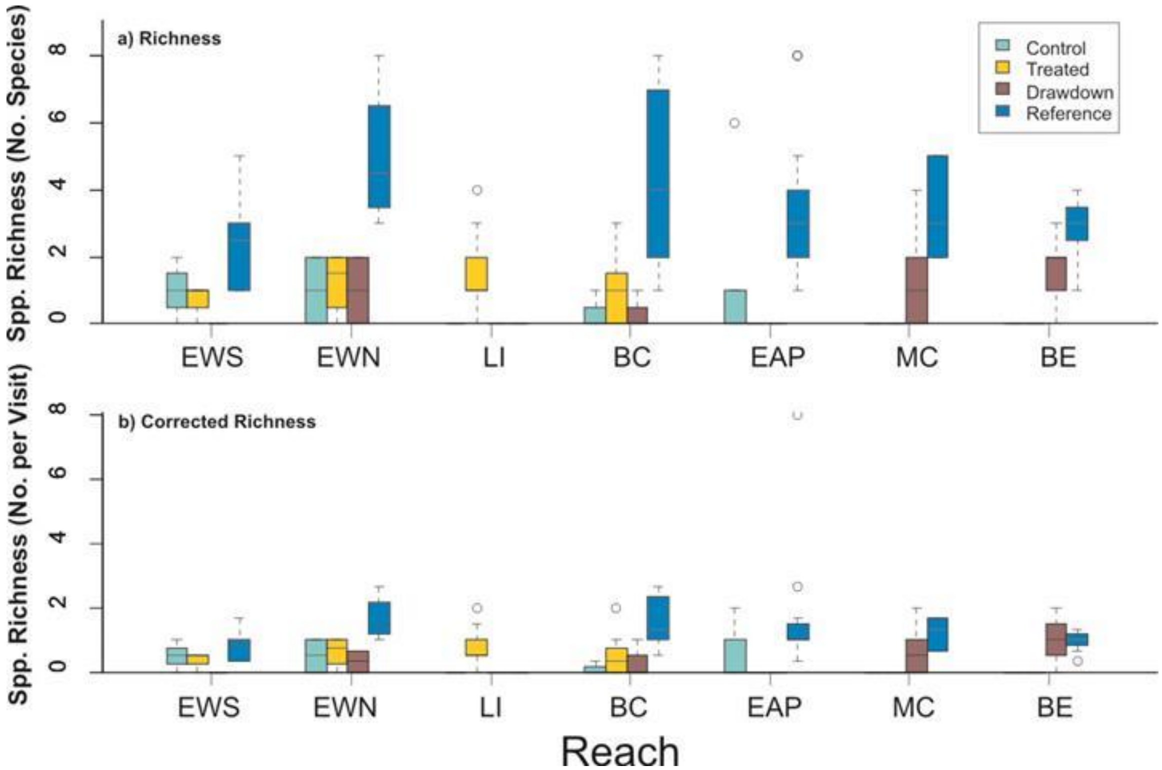

Figure 5-23. Variation in species richness of songbirds by reach and treatment a) number of species per point count, and b) corrected for sampling effort (number of species per point count per visit) in the Arrow Lakes Reservoir in 2013. Data represent songbird observations within 30 m of the point count centre

The relative abundance of songbirds (number of detections per point count) was higher in the reference point counts in Edgewood North, Burton Creek, and Mosquito Creek (Figure 5-24). Relative abundance was particularly low in the treatment plots of Edgewood South and East Arrow Park (where sampling occurred in treatment areas but did not detect any species, compared to Mosquito Creek and Beaton Arm where no treatment areas exist). Two-ways ANOVAs were performed between control and treatment plots only; differences in average relative abundance were not significant among reaches and years ($p > 0.05$), but the interaction of the two was significant ($F=3.35$, $p=0.03$). A series of one-way ANOVAs detected almost-significant differences among relative abundance in control and treated plots in East Arrow Park ($F=3.5$, $p=0.085$), and in Burton Creek ($F=4$, $p=0.076$).

Species richness is higher richness in reference sites than in drawdown sites. The ability to detect possible treatment effects is undermined by the lack of revegetation success at certain reaches (e.g., Burton Creek).

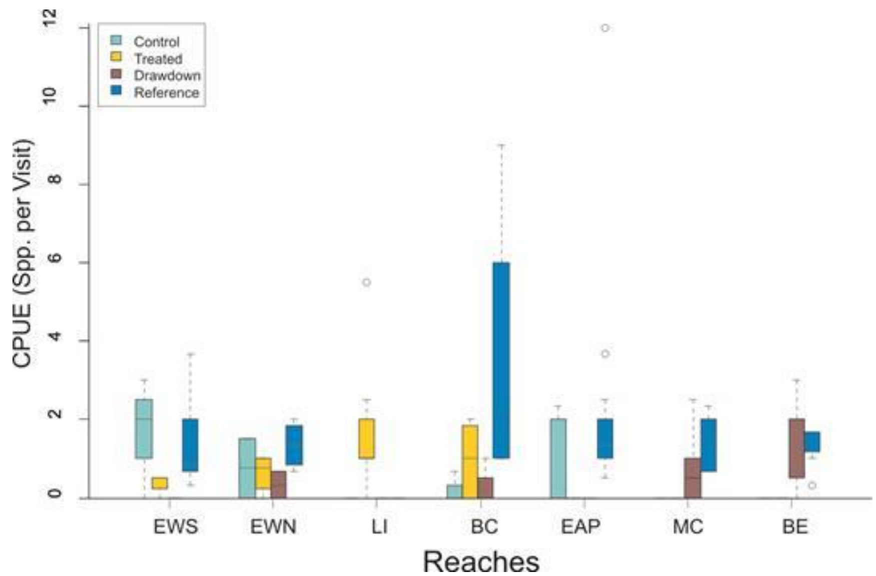

Figure 5-24. Variation in relative abundance (counts per visit) of songbirds by reach and treatment in the Arrow Lakes Reservoir in 2013. Data represent songbird observations within 30 m of the point count centre

Mirroring the abundance results, diversity was much higher in the reference plots than in the plots sampled in the drawdown zone, especially in Edgewood North, Burton Creek, East Arrow Park, Mosquito Creek, and Beaton Arm (Figure 5-24), but the differences among control and treatment plots were not significant (p> 0.05). Evenness followed similar patterns, with more variation within type of plots likely because of the high presence of zeroes (Figure 5-24). Evenness was higher in Burton Creek, East Arrow Park and Mosquito Creek; though none of the differences were statistically significant (p> 0.05).

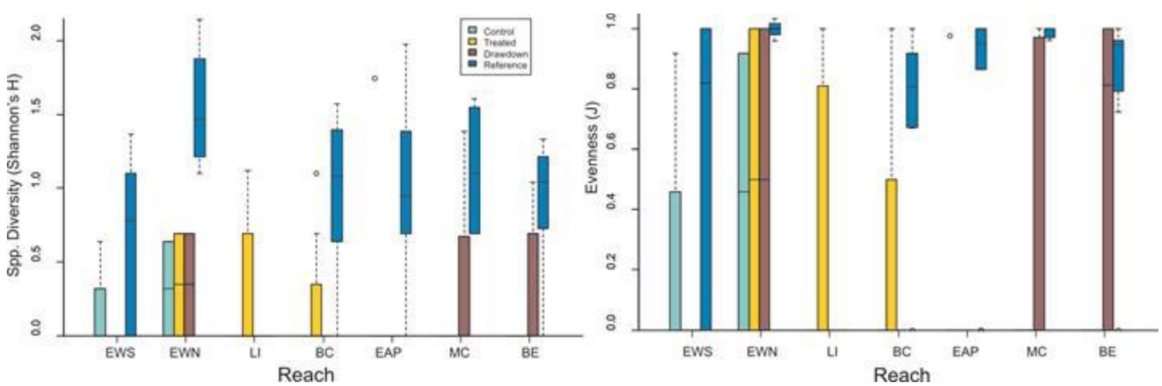

Figure 5-25. Variation in species diversity (Shannon H; left) and Evenness (J; right) of songbirds among types of plot and reaches in Arrow Lakes Reservoir in 2013. Data represent songbird observations within 30 m of the point count centre

5.2.6.3 Community Similarity

The community similarity among reaches and plot type was assessed based on songbird species compositions with two different similarity coefficients (D14 and D17), and with results superposed on a PCoA diagram. The two coefficients give different weights to rare and abundant species.

Both coefficients produced the same clustering, which suggests that rare and abundant species of songbirds had similar weight in the computation of community similarities. The control, treatment and drawdown plots in Edgewood North appear to have a distinct species assemblage, compared to the other reaches and plots (Figure 5-26, left). The reference plots from all reaches clustered together (with the drawdown zone in Mosquito Creek), indicating that they shared more similarities together than with the drawdown zone of their own reach.

In 2013, reference sites continued to cluster together as they did in previous years. Differences in songbird communities in other plot types show some differences among years, which could be due to natural variation in the songbird community or to a lack of influence of the treatments on songbird community similarity. More data are required to identify trends (if any) relative to community similarity.

Figure 5-26. Principal Coordinate Analysis (PCoA) ordination diagram representing songbird community similarity for each reach and treatment as computed by the Bray-Curtis distance (D14; left) and the Hellinger-Euclidian distance (D17; left). D14: Axis X expresses 18 per cent of the variation of the data set, and axis Y, 12 per cent. D17: Axis X, 17 per cent; axis Y, 12 per cent. Colors refer to treatment [green: drawdown zone (DDZ), black: control (CON), blue: reference (REF), red: treated (TRE)]. BE = Beaton Arm; BU = Burton Creek; EA = East Arrow Park; EN = Edgewood North; ES = Edgewood South; LI = Lower Inonoaklin; MC = Mosquito Creek

5.2.6.4 Songbird species assemblages

Understanding how songbirds partition themselves between the drawdown zone and upland reference sites will help determine the magnitude and direction of observed treatment effects after several years of data collection. The overall test of independence associated with Kendall's coefficient of concordance (W) showed that several songbird species were concordant (W=0.14, p=0.00001). As in previous years, songbird species appear to mainly split in two groups according to K-Means partitioning and PCA: drawdown zone species, and upland species (Figure 5-27), which is also consistent with the results shown on the PCoA above.

At least some of the species within each group were concordant with each other, and seem to represent closely specific treatment and reaches (group 1: $W=0.35$, $p=0.0001$; group 2: $W=0.127$, $p=0.048$). Group 1 species consist of those associated with the reference zone in all the reaches. Group 2 is composed of species found in the drawdown zone, both in control and treated sites. After correction for multiple testing, no species were still significantly concordant in group 2 (at $\alpha=0.05$), but six species were concordant with each other in group 1. Those six species are clearly associated with reference sites (Figure 5-27), with the exception of the drawdown zone in Mosquito Creek that is associated to a high concentration of MACW, and the control plots in East Arrow Park that were associated with AMRO and SWTH. Several of these species were also concordant in 2010 and 2011 (CAVI, CBCH, DEJU, GCKI, HAFL, see Appendix 10-D for an expansion of bird codes).

The natural variation associated with songbird species presence and relative abundance may result in minor changes to the groups of songbirds that partition between drawdown zone and upland habitats; however, the persistence of several species within each group suggests that these species can be tracked over time and used to assess revegetation effectiveness.

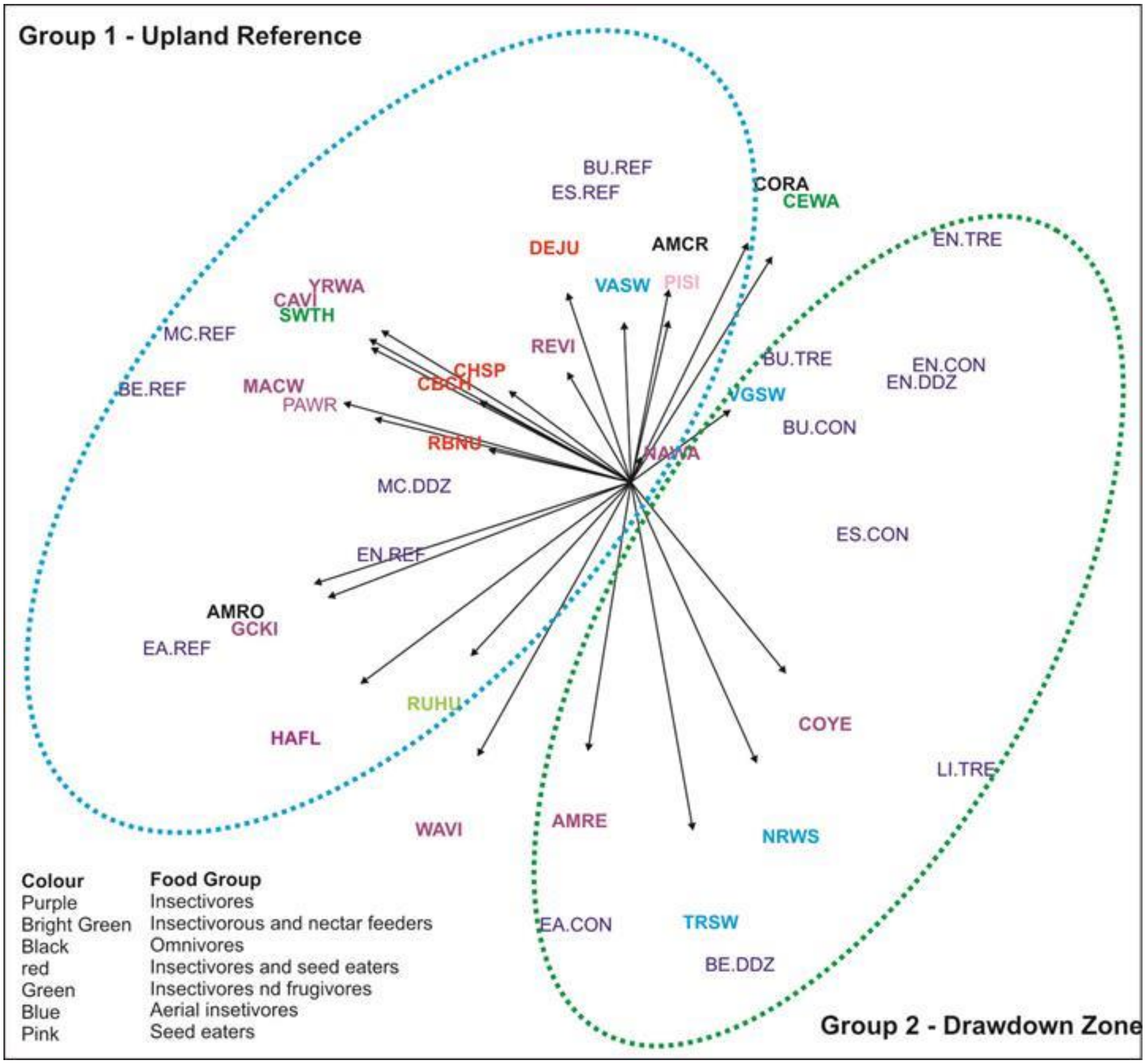

Figure 5-27. Principal Components Analysis ordination diagram with superposition of the partition results by K-Means. Black vectors represent species. Sites acronyms can be found in Figure 5-26. Groups as formed by K-Means and analysed by Kendall W are indicated by the coloured ellipses (blue for Group 1 and green for Group 2). Axis X expresses 21 per cent of the variation of the data set, and axis Y, 14 per cent

5.2.6.5 Songbird food habits

Many songbird species feed on arthropods, and the relationship between arthropod biomass and songbird communities can be relatively well-understood (e.g., Holmes et al. 1979; McMartin 2000). Revegetating the drawdown zone of mid- and lower Arrow Lakes Reservoir should first affect arthropod communities (as measured by changes in biomass, species richness and diversity; see Section 5.2.3). These changes should be followed by a measureable change in either the songbird communities or the relative abundance of certain species associated with the two groups identified in Table 5-6.

Songbirds can be grouped by their food habits (Table 5-6). As in previous years, no apparent association between revegetation treatment and songbird food preference was observed (i.e., birds that feed primarily on insects were not strongly correlated with treatment sites). However, the relative abundance of certain bird species was highest in the reaches where treatments were applied. These species are insectivores, aerial insectivores, or insectivores and seed eaters; arthropods comprise all or a substantial component of each of these species diet.

Table 5-6: List of songbird species per food group[1] in 2013. Species in this table are the same as those depicted in Figure 5-27. Species codes are defined in Appendix 10-D

Food Group	Species Code
Aerial Insectivores	BLSW, DUFL, HAFL, NRWS, TRSW, VASW, VGSW, WIFL, WWPE
Insectivores and Frugivores	CEWA, SWTH
Insectivores and Nectar feeders	RUHU
Insectivores and Seed eaters	AMPI, BCCH, CBCH, CHSP, DEJU, RBNU, SAVS, SOSP
Insectivores	AMRE, CAVI, COYE, GCKI, MACW, NAWA, PAWR, REVI, TOWA, WAVI, WIWA, YEWA, YRWA
Omnivores	AMCR, AMRO, CORA
Seed eaters	PISI

[1] Food groups were determined from Campbell et al. 1990a, b, 1997, and 2001.

The relative abundance of songbirds that are insectivores, aerial insectivores, or insectivores and seed eaters was correlated with one or more orders of arthropods sampled in 2013 (Figure 5-28). For example, the relative abundance of Western Wood-Pewee (WWPE), Yellow Warbler (YEWA), and American Pipit (AMPI) was positively correlated with the biomass of Odonata and Trichoptera while the relative abundance of American Redstart (AMRE) and Common Yellowthroat (COYE) was positively correlated with Diptera, Lepidoptera, and Coleoptera. Some of these relationships were the same in 2010 and 2011, supporting the notion that these bird and arthropod species and orders can be monitored at these reaches and treatments to assess ecological relationships and those relationships can be used to assess revegetation effectiveness over time.

There appears to be a clustering of bird species (Savannah Sparrow, Dusky Flycatcher, Common Yellowthroat and American Redstart) at Edgewood and

East Arrow while Violet-green Swallow, Black Swift, and Vaux's Swift are were more abundant Burton Creek, Beaton Arm, and Edgewood South upland reference sites. Likewise, the relative abundance of three species (Chestnut-back Chickadee, Nashville Warbler, and Chipping Sparrow was highest at Mosquito Creek (drawdown zone and upland) and was correlated with a high abundance of spiders (Aranea), Opiliones (harvestmen), and Neuroptera (net-winged insects).

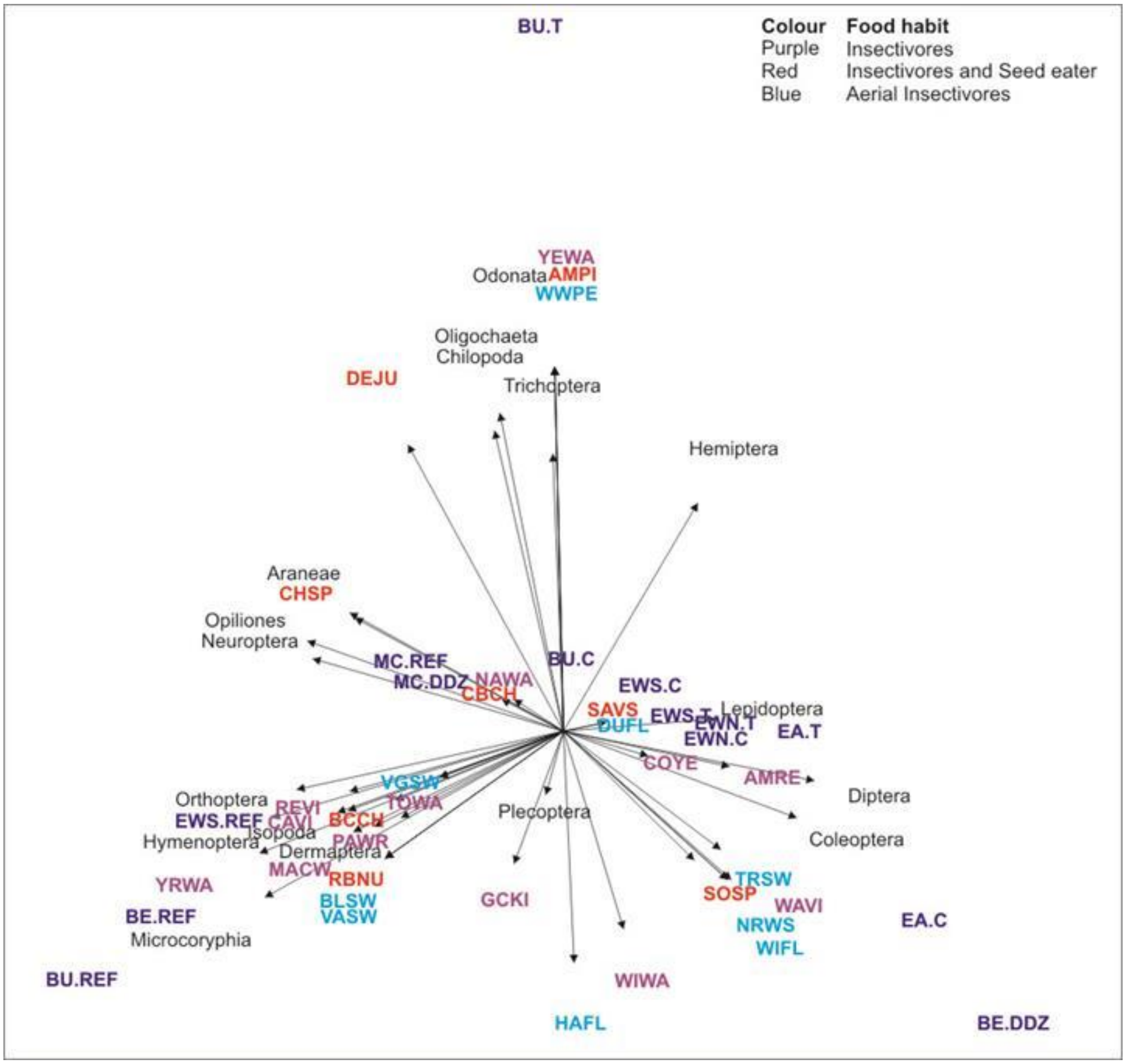

Figure 5-28: Principal Components Analysis ordination diagram with superposition of songbird species (colour-coded by food habit) and arthropod orders. Black vectors represent species. Axis 1 represents 31 per cent and axis 2 17 per cent of the variation in the multi-dimensional data set. Scaling is of type 2. BU.TRE = treatment sites, Burton Creek, BU.CON: control sites, Burton Creek of Burton, BU.REF: reference sites, Burton Creek; BE.DDZ: Drawdown sites, Beaton, BE.REF: reference sites, Beaton; EA.TRE: treatment sites, East Arrow Park, EA.CON: control sites, East Arrow Park; EN.TRE: treatment sites, Edgewood North; ES.TRE: treatment sites, Edgewood South, ES.CON: control sites, Edgewood South. Bird species codes are defined in Appendix 10-D

5.2.7 Mammals

5.2.7.1 Bats

From the recordings collected during the sampling period a total of 97,288 .wav files were extracted using Kaleidoscope Pro (Version 1.1.20) – Wildlife Acoustics' proprietary bat analysis software. Of these, 52,145 files were labelled as noise during processing in Kaleidoscope Pro. The remaining 45,143 files that could be attributed to bats were largely unidentifiable to species, with 10,001 recordings classified to species. The number of calls assignable to a species or group of bat ranged from ~7 per cent at Burton Creek to ~11 per cent at Beaton arm (Figure 5-29). The potential species identifications are determined through a comparative analysis using bat classifiers, so the accuracy of the results depends on the quality of the recordings. Consequently, the results generated reflect the overall bat activity at each reach and potential suite of species that utilize the drawdown zone at each location. It does not, however, account for such external factors as the local weather which can affect the quality of the recordings and cause misidentifications.

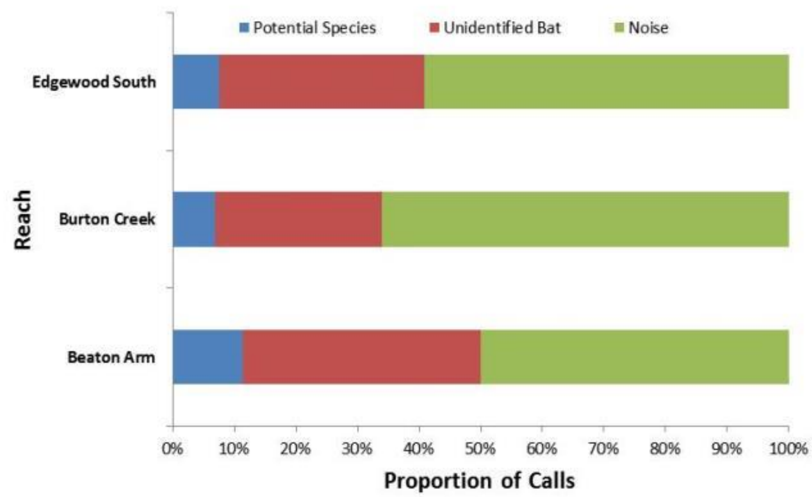

Figure 5-29: Proportion of recordings collected from the drawdown zone of mid- and lower Arrow Lakes Reservoir in summer 2013 assigned as noise, unidentifiable bat, or to a species or genus of bats (i.e., potential species)

Ten species of bat were assigned to the recordings and considered potential species (Table 5-7). Nine of the ten species were documented from each reach sampled, with one species, Townsend's big-eared bat (*Corynorhinus townsendii*) also potentially occurring only at Burton Creek (in 2011 this species only occurred at Beaton Arm). Of the species documented, two have current provincial conservation designation: Townsend's big-eared bat and Western Small-footed Myotis (*Myotis ciliolabrum*) are blue-listed in British Columbia. The blue-list includes any ecological community, and indigenous species and subspecies considered to be of special concern (formerly vulnerable) in British Columbia. Species are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed elements are at risk, but are not Extirpated, Endangered or Threatened. A third species, Little Brown Myotis (*M. lucifugus*) is listed as endangered by COSEWIC, primarily because of the increasing threats this species faces from disease (e.g. white-nosed fungal epidemic).

Table 5-7: Bat species documented at each reach sampled in mid- and lower Arrow Lakes Reservoir in 2013. An “X” indicates the species was recorded at the corresponding reach location. BE = Beaton Arm; BU = Burton Creek; ES = Edgewood South

Common Name	Scientific Name	Code	CDC[1] Status	COSEWIC[1] Status	Reach		
					BE	BU	ES
Townsend's big-eared bat	*Corynorhinus townsendii*	COTE	Blue	N/A		X	
Big brown bat	*Eptesicus fuscus*	EPFU	Yellow	N/A	X	X	X
Silver-haired bat	*Lasionycteris noctivagans*	LANO	Yellow	N/A	X	X	X
Hoary bat	*Lasiurus cinereus*	LACI	Yellow	N/A	X	X	X
California myotis	*Myotis californicus*	MYCA	Yellow	N/A	X	X	X
Western small-footed Myotis	*Myotis ciliolabrum*	MYCI	Blue	N/A	X	X	X
Western long-eared myotis	*Myotis evotis*	MYEV	Yellow	N/A	X	X	X
Little brown myotis	*Myotis lucifugus*	MYLU	Yellow	Endangered	X	X	X
Long-legged myotis	*Myotis volans*	MYVO	Yellow	N/A	X	X	X
Yuma myotis	*Myotis yumanensis*	MYYU	Yellow	N/A	X	X	X

At Beaton Arm the majority of calls were produced by the six Myotis species and Hoary, Big brown, and Silver-haired bats were less prevalent (Figure 5-30). At Burton Creek these species were more prevalent than the Myotis group. A single Townsend's big-eared bat (COTE) recording was obtained from Burton Creek. With the exception of Townsend's big-eared bat, a similar pattern was observed at Edgewood South. The relative ubiquity of Myotis species at all reaches sampled suggests that this group of bats may be suitable for future monitoring.

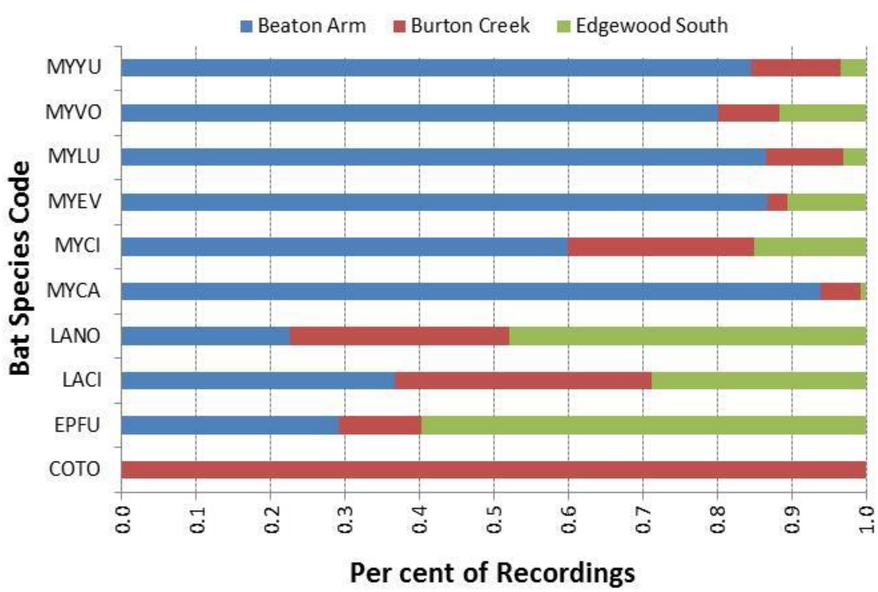

Figure 5-30: Proportion of recordings assigned to a given bat species at each reach sampled in mid- and lower Arrow Lakes Reservoir in 2013. See **Table 5-7** for expanded species codes

The relative abundance (recordings per hour) of bat species by reach did not reveal any obvious trends other than Little Brown Bat (MYLU) was the most commonly recorded bat species at all of the reaches sampled (Figure 5-31, top), which is consistent with data collected in 2011 (Hawkes et al. 2012). California myotis (MYCA) was the next most common species at all sites followed by Yuma myotis (MYYU). The most common large bat species at all sites was silver-haired bat (LANO). The detection rates of each species varied by recording time with some species (e.g., LANO, LACI, EFPU) more active at night while other species (e.g., MYLU, MYCA) were active in all time periods (Figure 5-31, bottom).

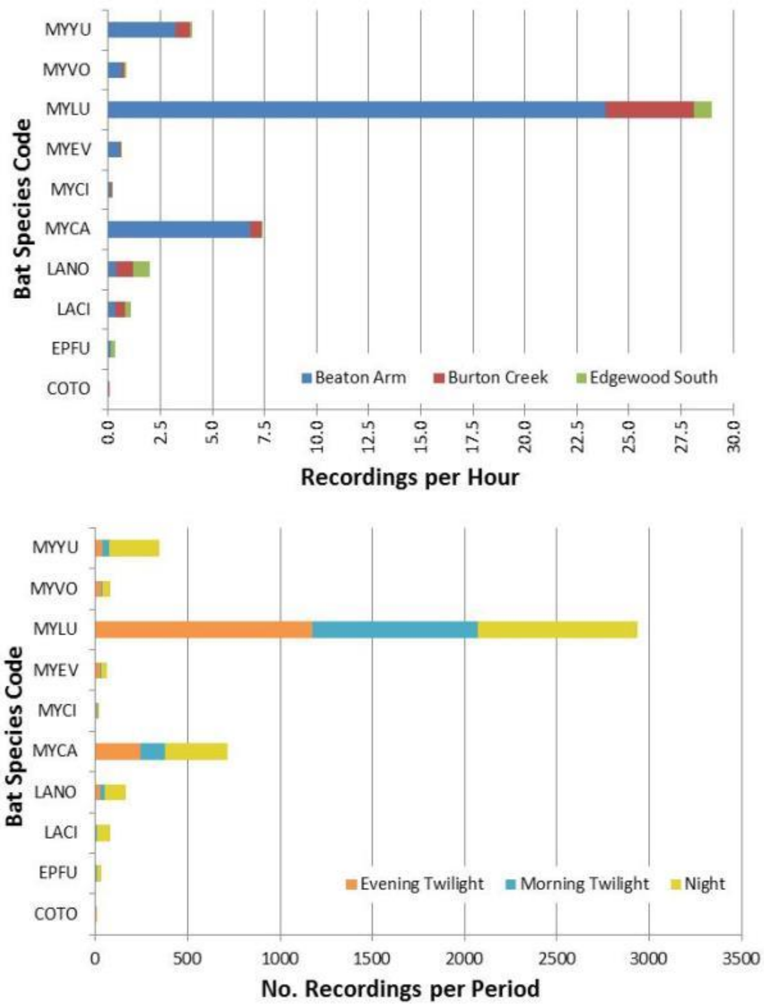

Figure 5-31: Relative abundance (number of recordings per hour) for bat species documented in the drawdown zone of mid- and lower Arrow Lakes Reservoir, summer 2013 (top panel) and for each time period (bottom panel). See **Table** 5**-**7 for expanded species codes

5.2.7.2 Ungulate Pellet Plots

Surveys were completed on May 25, 2013. A total of 34 stations from 6 transects (3 treatment and 3 control) were sampled with 21 deer spp. fecal pellet groups and 10 deer spp. tracks counted (Table 5-8; Appendix 10-B). The only ungulate species detected were deer spp. [either White-tailed Deer (*Odocoileus* *virginianus*) and/or Mule Deer (*Odocoileus hemionus*)]. Observation of two coyote scats and two tracks were counted within the pellet plots. The majority of pellet groups were detected in control sites at Burton Creek and Edgewood South. Deer tracks were observed in the treatments at Lower Inonoaklin Road and Edgewood South.

Table 5-8: Total fecal pellet groups and tracks by reach and transect type recorded in the Arrow Lakes Reservoir, 2013. Deer species (White-tailed and Mule deer) are pooled due to difficulty in differentiating these species by pellets

Species	Sign	Burton		Lower Inonoaklin		Edgewood South		Total
		Control	Treatment	Control	Treatment	Control	Treatment	
Coyote	**Pellet**					1	1	**2**
	Tracks						2	**2**
Deer Spp.	**Pellet**	10		1	1	9		**21**
	Tracks			3	4		3	**10**
	Site Total	**10**	**0**	**4**	**5**	**10**	**6**	

The relative abundance of observations (pellet group and track counts per plot) was calculated by dividing the number of observations per site and treatment type by the number of stations per transect (Figure 5-32). Across surveyed areas, less pellet groups were observed treatment areas compared to controls. In fact, 20 of the 21 pellet groups counted were in control areas.

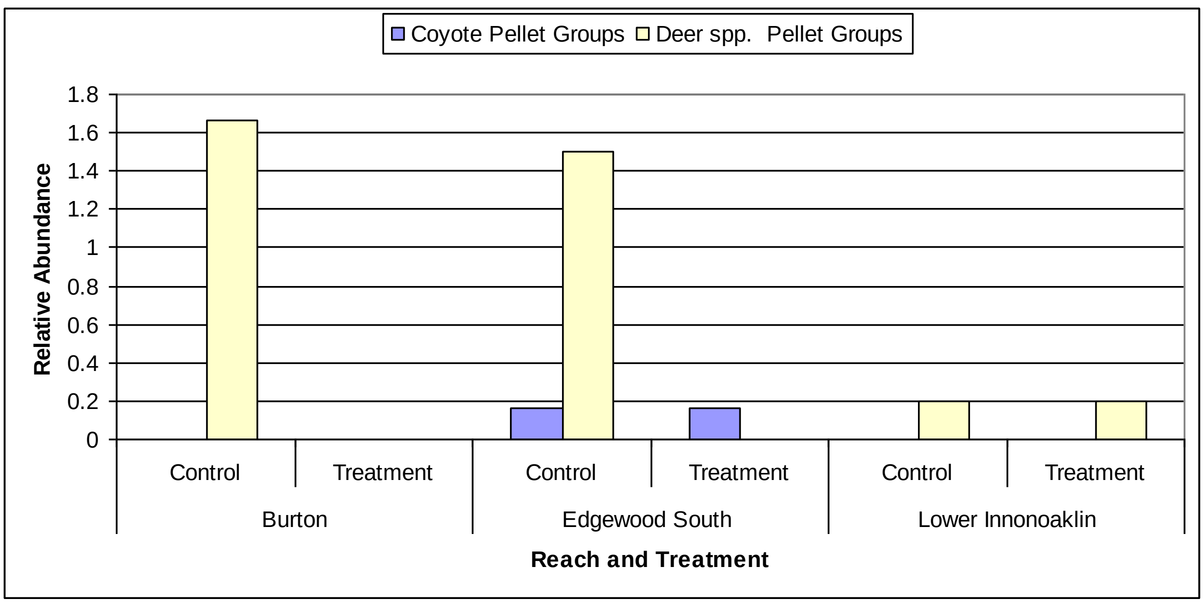

Figure 5-32: Relative abundance of fecal pellet groups and tracks by site and transect type in the Arrow Lakes Reservoir, 2013. Deer pellets cannot reliably be identified to species, but together can be differentiated from other ungulates

5.2.8 Amphibians and Reptiles

No surveys for amphibians and reptiles were conducted in 2013. However, we continued to make incidental observations at all reaches sampled in mid- and lower Arrow Lakes Reservoir. Amphibian and reptile data will be collected again in 2014 using a standardized approach (as per CLBMON-37). Notable observations included the presence of breeding Western Toads (*Anaxyrus boreas*) at Burton Creek (and the observation of tadpoles and toadlets throughout the year) and observations of numerous garter snakes (both *Thamnophis elegans* and *T. sirtalis*) at Edgewood South. These observations were consistent with those reported in Hawkes et al. (2012).

6.0 DISCUSSION

CLBMON-11B1, initiated in 2009, is a long-term wildlife monitoring project that aims to assess the efficacy of revegetation prescriptions in enhancing the suitability of habitats in the drawdown zone for wildlife, and to develop a minimum of three wildlife enhancement prescriptions that can be implemented in the drawdown zone to further improve habitat suitability. The focal species groups selected for this study are songbirds, arthropods and mammals (ungulates). In addition to studying these groups, bats were incorporated into the 2010 sampling program because of the known relationships between bats, wetland and riparian habitat, and arthropods, which are their primary food source. In 2013 we sampled the same suite of wildlife as in previous years; however, we did not conduct aerial surveys for ungulates.

The revegetation prescriptions applied in the drawdown zone are likely to affect prey populations (terrestrial and aerial arthropods) before they affect the predators of those arthropods (songbirds and bats). The direction and magnitude of those changes in arthropod populations will be tracked over time and will serve as a metric to assess the efficacy of each revegetation prescription applied in the drawdown zone.

Specific revegetation prescriptions (live stakes) may increase the volume of ungulate browse in the drawdown zone, which is why ungulates are included in the long-term monitoring program. Pellet plots installed in 2011 were counted and cleared in 2013. Few pellets were counted and those that were deposited by deer species and were almost always counted in the controls. There appeared to be little to no use of the revegetated areas by ungulates. This could be confounded by the fact that the treatment areas get inundated each year, but the presence of pellet groups in the control areas suggests this may not be the case.

In general there does not appear to be a strong relationship between the biomass of arthropods or the relative abundance of songbirds and revegetation prescriptions applied in the drawdown zone, which is consistent with Hawkes et al. (2012). There are distinct groupings of both arthropods and songbirds that partition themselves along an environmental gradient representing the drawdown zone and adjacent upland habitats; these groupings were consistent with previous years (see Hawkes et al. 2011a, 2012). The inherent natural variation associated with communities of songbirds and arthropods and the relatively short time since the revegetation prescriptions were applied are likely contributing to the lack of observed patterns. More time is required to assess how species richness, biomass, and relative abundance change as a result of the implementation of the revegetation prescriptions.

Songbirds and arthropods are likely suitable indicators to assess changes in habitat quality induced by the revegetation prescriptions. This is based on the persistence of distinct drawdown zone and upland songbird and arthropod communities and on the relationships between songbirds and their arthropod prey. Although density independent events appear to be affecting the biomass of arthropods (e.g., wind or rain events may have affected the total catch of arthropods in 2011 and 2013), a temporal data set consisting of multiple years should indicate how arthropod biomass is changing and whether that change can be correlated to treatments.

Monitoring the use of the drawdown zone by bats has resulted in the documentation of 10 bat species in various locations in mid- and lower Arrow Lakes Reservoir. The data we have collected to date is not correlated with a specific treatment. Rather, the data provide an overview of the distribution and occurrence of bat species using the drawdown zone of Arrow Lakes Reservoir. The ability to correlate the presence of bats to arthropod biomass is confounded by the fact that data collected from passive acoustic monitoring may not be correlated to bat abundance. Using the number of detections per hour is only a proxy for bat activity, which may not be correlated with food availability.

The effectiveness monitoring program developed and implemented in mid- and lower-Arrow Lakes Reservoir should continue, but some changes are recommended, particularly with respect to the indicator taxa (see Recommendations). These methods should also be appropriate for monitoring the efficacy of proposed wildlife physical works promoted in Hawkes and Howard (2012). Recommendations regarding these refinements are provided in Section 7.0.

6.1 Management Questions and Hypotheses

6.1.1 Are the revegetation and the wildlife physical works projects effective at enhancing wildlife habitat in the drawdown zone?

6.1.1.1 Revegetation

Based on the results obtained in 2013 it is not clear if the revegetation prescriptions are enhancing wildlife habitat in the drawdown for the taxa being monitored. The relative abundance of arthropods does not vary between control and treatment areas and in most cases, the relative abundance, species richness, and biomass of arthropods was higher in control than treatment areas. There is a distinction between the drawdown zone and upland reference sites (which is expected) and the ability to detect differences in the relative abundance of arthorpods using existing methods remains. However, it is probably more relevant to study ground-dwelling insects (i.e., spiders and beetles) as they are more likely to respond to changes in vegetation cover over time.

The relative abundance of songbirds varies between the drawdown zone and upland reference sites and over time, a result that is expected. The relative abundance of songbirds at each reach has not varied since the start of this monitoring program (2009). Moreover, the relative abundance of songbirds at the treatment level has not varied, other than there being more birds in the drawdown zone, which is likely a function of access to prey for certain species. Although these results appear to suggest that there is no effect of revegetation applied in the drawdown zone of Arrow Lakes Reservoir, a longer-time series of data is required to assess this. Additionally, studying nesting success of grass and ground-0nesting birds may provide more relevant data with respect to the efficacy of revegetation prescriptions to provide habitat for birds.

The revegetation treatments applied in the drawdown zone are not likely to enhance habitat for ungulates. Those revegetated areas may be used by ungulates, but at present it appears that ungulates are avoiding the revegetated areas and using the control sites only and it is not clear why this is happening. Previous disturbance of the site may have influenced the use of the treatments by ungulates, but any disturbance-related effects would have likely dissipated by now. The proximity of suitable ungulate habitat upslope form the drawdown zone (Hawkes et al. 2011) suggests that vast areas of the drawdown zone would need to be revegetated to influence the use of the drawdown zone by those species. Given that ~70 ha were revegetated, it is unlikely that the use of the drawdown zone will increase as a function of the revegetation program.

If ungulate use of the drawdown zone is considered to be a critical measure of the success of this project, then measures to enhance wildlife habitat in upland areas adjacent to the drawdown zone may be of greater benefit to overall ungulate populations than would enhancement of drawdown zone habitats. Options for enhancing upland ungulate habitat include prescribed burning and brushing/slashing prescriptions, both of which remove overgrown and decadent vegetation from the understory and allow for an increase in fresh growth, which acts as both cover and a food source. These types of prescriptions were investigated as potential wildlife enhancement projects, and they continue to be considered for development of a wildlife enhancement strategy for mid- and lower Arrow Lakes Reservoir. However, they have not been promoted as priority enhancement projects by Hawkes and Howard (2012) and are retained for future consideration (Hawkes et al. 2012).

From a revegetation perspective, the application of treatments in the drawdown zone does not appear to influence the use of the drawdown zone by songbirds, arthropods, or ungulates. There are several reasons why this might be: 1) the size of the revegetation treatments and their proximity to upland forest may limit their use by wildlife; 2) If wildlife are using the drawdown zone, the extent to which they do does not appear to influenced by the revegetation areas, which could again be influenced by the type of revegetation prescription (e.g., live stake vs. plug seedling), which may not provide a superior alternative to the types of habitats that already occur in the drawdown zone or adjacent habitats; 3) the lack of replication at the treatment level makes it difficult to detect a signal, even if one exists. Presently, the size of the effect that would have to be present to be measured is considered to be very large (i.e., >50 per cent change in the metric being assessed). This size of change has not been detected; and 4) the success of the revegetation program in Arrow Lakes Reservoir is equivocal and not enough time has passed to assign any level of success to that program (Enns and Enns 2012). Until more data are collected to assess the effectiveness of the revegetation program, we will not be in a position to assess the effectiveness of the revegetation program to enhance habitat for wildlife.

6.1.1.2 Physical Works

Physical works have not yet been implemented at this stage in the project. Several potential wildlife physical works were identified (Hawkes and Howard 2012), but until they are implemented and monitoring is initiated we cannot answer this part of the management question.

6.1.2 If revegetation and the wildlife physical works projects enhance wildlife habitat in the drawdown zone, to what extent does the revegetation program and the wildlife physical works projects increase the productivity of habitat in the drawdown zone for wildlife?

6.1.2.1 Revegetation

Based on the answer to management question 1 (above), it is not clear if the revegetation program has enhanced the drawdown zone for wildlife, although it is unlikely to do so for ungulates. The biomass of arthropods was used as proxy for productivity in 2013, biomass in treated areas was lower than in controls. This result was driven largely by the data collected in pitfall traps, which are considered to be better indicators of revegetation effectiveness than data collected in Malaise traps. The species crawling on the ground are not as likely to be influenced by wind (which will affect flying insects). More data are required to determine if the results obtained in 2013 are indicative of a treatment effect (one that actually reduces the suitability of the drawdown zone for arthropods) or due to natural variation.

6.1.2.2 Physical Works

Physical works have not yet been implemented at this stage in the project. Several potential wildlife physical works were identified (Hawkes and Howard 2012), but until they are implemented and monitoring is initiated we cannot answer this part of management question

6.1.3 Are some methods or techniques more effective than others at enhancing wildlife habitat in the drawdown zone?

6.1.3.1 Revegetation

The application of the revegetation prescriptions does not support a treatment-specific assessment of effectiveness The ability to answer this question is hampered by the relatively small number of areas treated in the drawdown zone, the size of the areas treated, and the lack of replication associated with each revegetation prescription. This limits the ability to use inferential statistics to determine whether some methods are more effective than others. The best we can do is assess habitat suitability at each site and correlate that to the type of revegetation prescription applied. At present, it is unknown if live-staking or plug seedling prescriptions will be more effective at enhancing wildlife habitat in the drawdown zone and more data are required to assess this.

6.1.3.2 Physical Works

Physical works have not yet been implemented at this stage in the project. Several potential wildlife physical works were identified (Hawkes and Howard

2012), but until they are implemented and monitoring is initiated we cannot answer this part of management question.

6.2 Management Questions - Summary

Our ability to address each of the management questions is summarized below (Table 6-1). The methods used are appropriate for collecting data that can be used to answer certain questions. For others, additional approaches may be required. For example, to answer questions regarding songbird productivity, nest searches are suggested. In other cases, increasing the total area or number of areas revegetated would assist with problems associated with small sample size and small treatment areas. Continued monitoring of arthropod, songbird, and bat, populations in the drawdown zone should provide the necessary information to answer most management questions. Future sampling for ungulates (via aerial surveys or pellet plots) is not recommended because of the limited influence the revegetation prescriptions are likely to have on ungulate populations. Evidence of use can be obtained by recording ungulate sign when sampling for other taxa. Sampling in each year will remove uncertainty associated with bi-annual sampling and better characterize the year-to year variation of all taxa sampled. Modifications to the study are suggested that will provide the data necessary to answer the management questions.

Additionally, until the physical works are implemented in mid- and lower Arrow Lakes Reservoir, we will not be able to answer questions regarding their effectiveness.

Table 6-1: Relationships between management questions (MQs), methods and results, sources of Uncertainty, and the future of project CLBMON-11B1

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	**Suggested modifications to methods where applicable**	
1. Are the revegetation and the wildlife physical works projects effective at enhancing wildlife habitat in the drawdown zone?	Partially	Data collected in control, treatment, and upland reference sites indicate that wildlife are using all treatment areas; however, the relatively short time that has passed since the application of the revegetation prescriptions limits our ability to comment on the effectiveness of those prescriptions.	• Increased frequency of sampling (i.e., annually) • Pair autonomous acoustic monitors to sample control and treatment areas simultaneously	• Lack of appropriate baseline (sampling did not occur prior to the application of the revegetation prescriptions) • Natural annual population variation • Proximity of treatments to adjacent upland habitat • Lack of replication • Success of revegetation program • Bi-annual sampling • Variable reservoir operations • Physical works have not been implemented
2. If revegetation and the wildlife physical works projects enhance wildlife habitat in the drawdown zone, to what extent does the revegetation program and the wildlife physical works projects increase the productivity of habitat in the drawdown zone for wildlife?	Not at this time	It is unclear if the revegetation prescriptions are effectively improving wildlife habitat. As such, it is too early to determine if productivity has increased. Data obtained in 2013 indicate that this may not be the case, at least for arthropods.	• Increased frequency of sampling (i.e., annually) • Include nest searches to study bird productivity • Pair autonomous acoustic monitors to sample control and treatment areas simultaneously	• Lack of appropriate baseline (sampling did not occur prior to the application of the revegetation prescriptions) • Natural annual population variation • Lack of productivity surveys for songbirds (i.e., nest searches) • Bi-annual sampling • Variable reservoir operations • Physical works have not been implemented

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	**Suggested modifications to methods where applicable**	
3. Are some methods or techniques more effective than others at enhancing wildlife habitat in the drawdown zone?	Not at this time	The application of treatment prescriptions in the drawdown zone does not support a treatment-specific assessment. The prescriptions applied were too small, not replicated, nor were they stratified.	• Consider adding replicates of certain revegetation prescriptions at some sites • Increase the size (total area treated) of some existing revegetation areas	• Lack of appropriate baseline (sampling did not occur prior to the application of the revegetation prescriptions) • Natural annual population variation • Variable reservoir operations • Physical works have not been implemented

7.0 RECOMMENDATIONS

1. **Consider modifying the sampling program of CLBMON-11B1 to occur annually.** This approach would ensure that appropriate before- and after-impact data are collected at the proposed physical works locations (i.e., Lower Inonoaklin Road, Edgewood South, and Burton Creek). Collecting songbird, and arthropod data on an annual basis would also 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). Once the proposed physical works are implemented, annual sampling at those locations would serve to assess the effectiveness of those physical works using a traditional before-after-control-impact (BACI) study design (Smith 2002).
2. **Remove ungulates as an indicator.** Future sampling for ungulates (via aerial surveys or pellet plots) is not recommended because of the limited influence the revegetation prescriptions are likely to have on ungulate populations. Evidence of use can be obtained by recording ungulate sign when sampling for other taxa
3. **Consider nest searches to study bird productivity** in the drawdown zone. Specifically target revegetated areas – Burton Creek, Lower Inonoaklin Road, and Edgewood South.
4. **Consider 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 sample size.

8.0 SARA-listed Species

8.1 Amphibians and Reptiles

The only amphibian at risk documented in the drawdown zone of Arrow Lakes Reservoir was the Western Toad, which is a species of Special Concern (as per SARA). The Columbia Spotted Frog (*Rana luteiventris*) is currently a COSEWIC status report candidate species (as of October 2010). The status of this species is not yet assessed, and populations are considered to be stable throughout its range.

Two species of reptiles with federal conservation status were documented in 2013, either in or near the drawdown zone of Arrow Lakes Reservoir:

1. The Intermountain–Rocky Mountain Population of the western Painted Turtle (*Chrysemys picta*) is blue-listed in British Columbia and is a federal species of Special Concern. This species has been documented using the drawdown zone of Arrow Lakes Reservoir in Revelstoke Reach from Airport Marsh south to Drimmie Creek.
2. The Western Skink is blue-listed in British Columbia and is a federal species of special concern. This species was documented from the drawdown zone of Arrow Lakes, near Edgewood, in the west-central portion of the reservoir. Data on Western Skink observations were provided to Brandon University for the preparation of COSEWIC status appraisal summary.

8.2 Birds

Three bird species with federal (COSEWIC) conservations status have been documented during songbird surveys throughout the years. Both Bank Swallow (*Riparia riparia*) and Barn Swallow (*Hirundo rustica*) have been documented during all project years, though were not federally listed until 2013 and 2011 respectively. Both species are currently listed as Threatened. A Horned Grebe (*Podiceps auritus*) was detected during songbird surveys in 2010, and is listed by COSEWIC as Special Concern.

While not documented during formal surveys, a Common Nighthawk, listed as Threatened, was seen incidentally near Beaton Arm in 2013.

The Barn Swallow is also blue-listed in BC, as are the Great Blue Heron (*Ardea herodias herodias*) and California Gull (*Larus californicus*) that were documented during songbird surveys in past years. Heron have only been documented once during surveys (2009), though gulls have been more frequently detected (all years except 2009).

8.3 Mammals

Grizzly bear is a species of Special Concern. This species was documented in the drawdown zone of Mosquito Creek and Edgewood South. The Western small-footed myotis is currently blue-listed in B.C. was documented from Burton Creek, Beaton Arm, and Edgewood South in 2013. Townsend's big-eared bat (*Corynorhinus townsendii)*, which is blue-listed in B.C., was documented in one location (Burton Creek) in 2013. The endangered Little-brown myotis was detected at Burton Creek, Beaton Arm, and Edgewood South.

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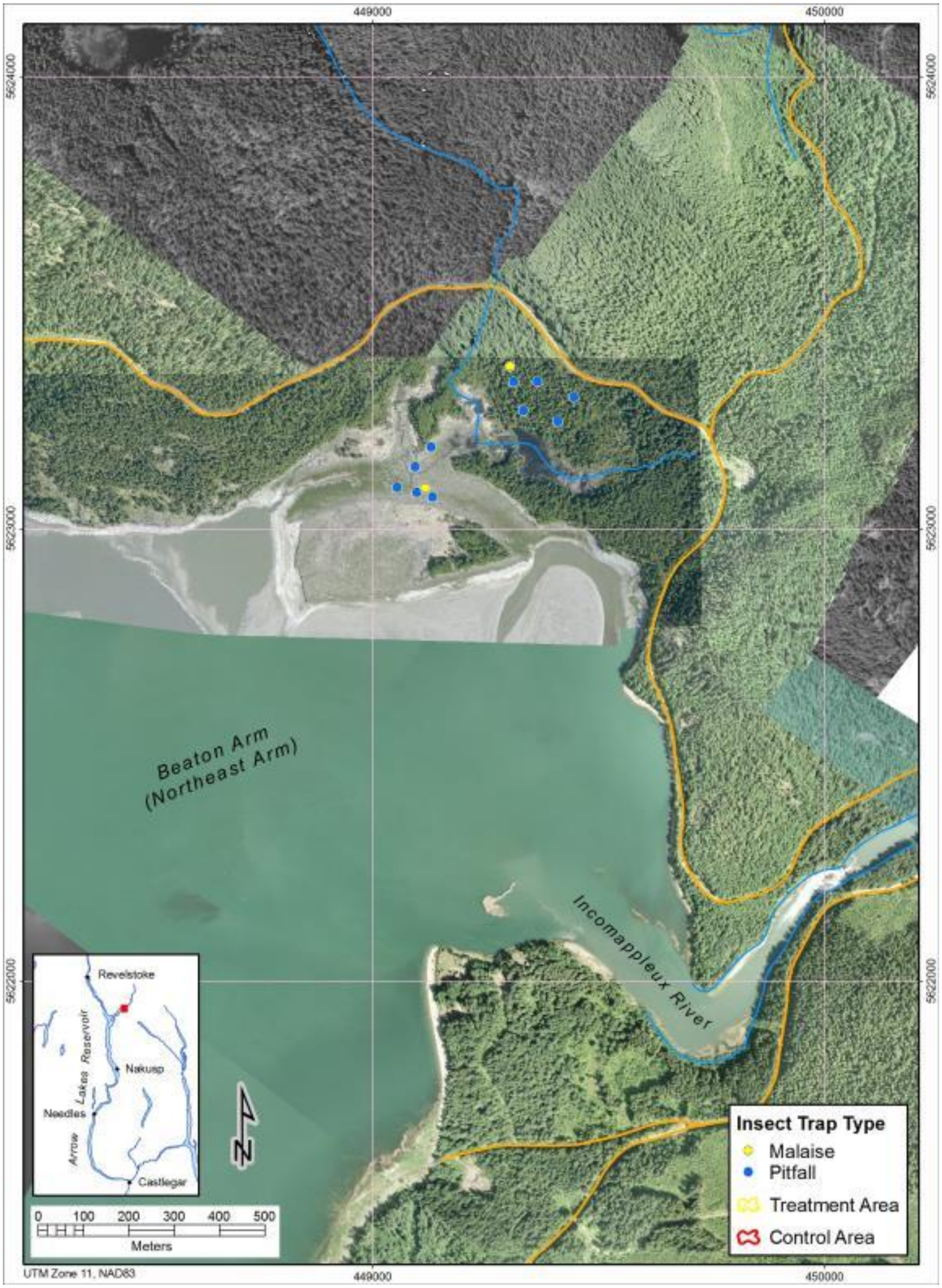
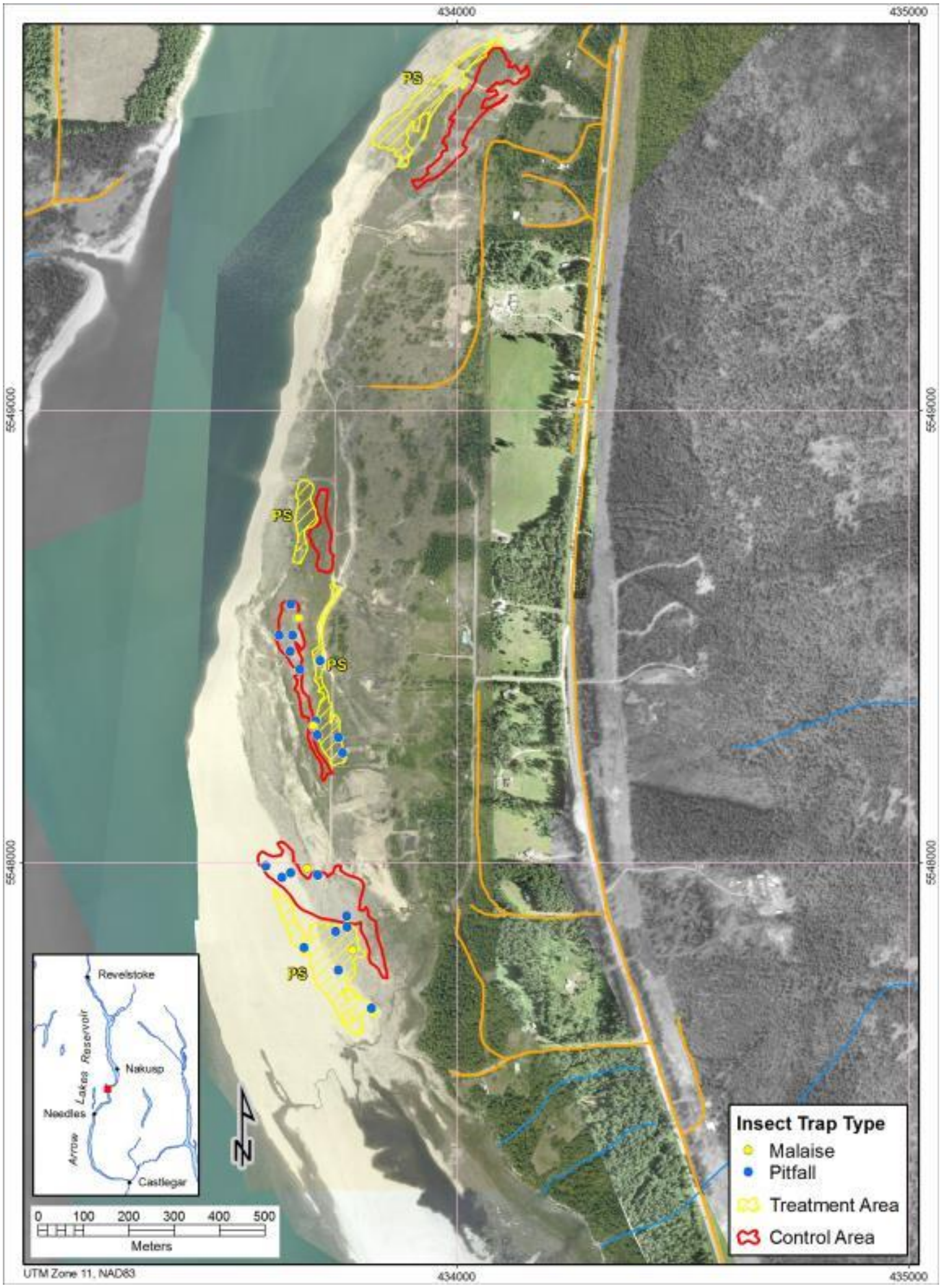
10.0 APPENDICES

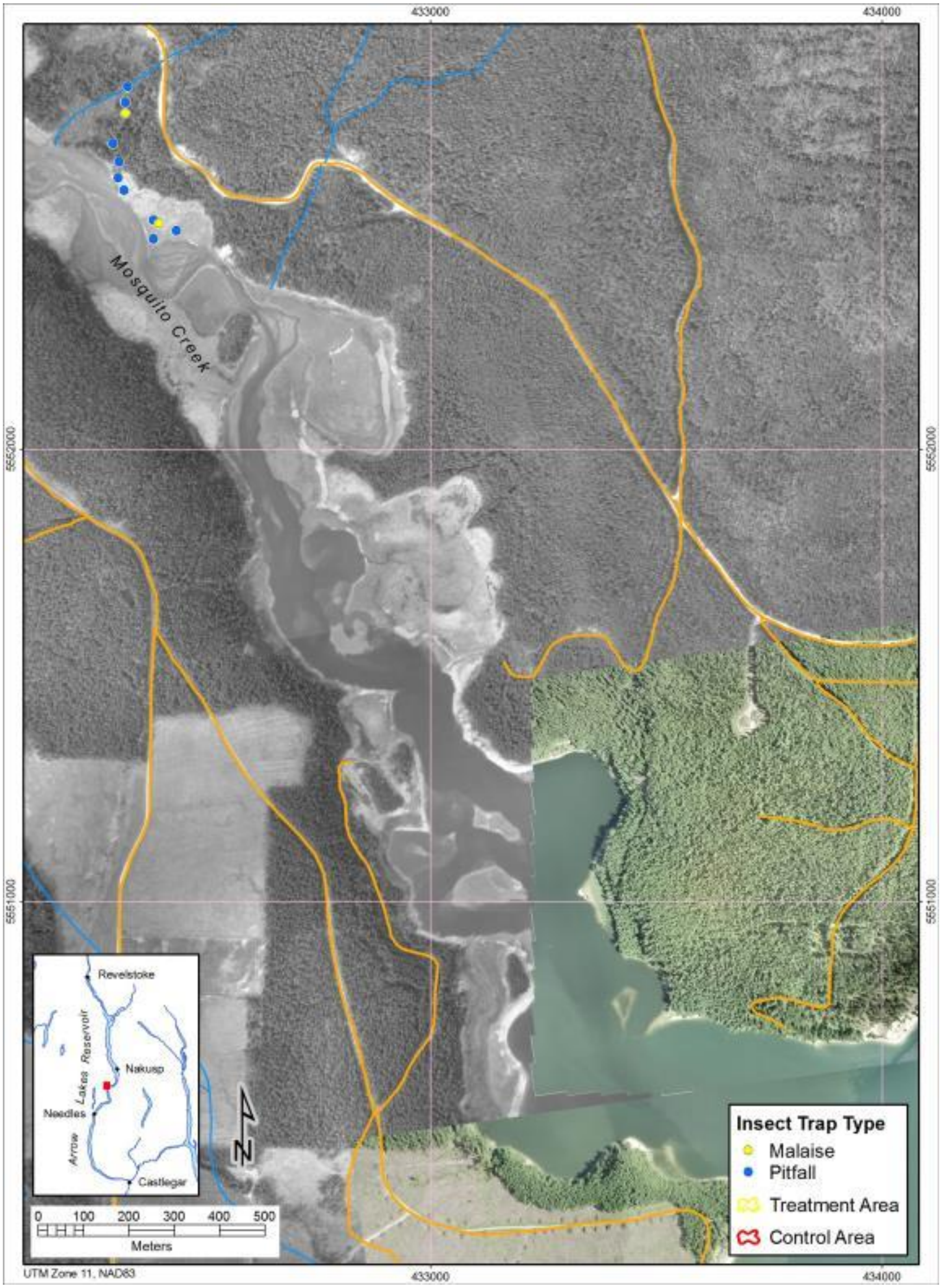
10.1 Appendix 10-A: Maps depicting Malaise and pitfall trapping locations for all reaches sampled in 2013



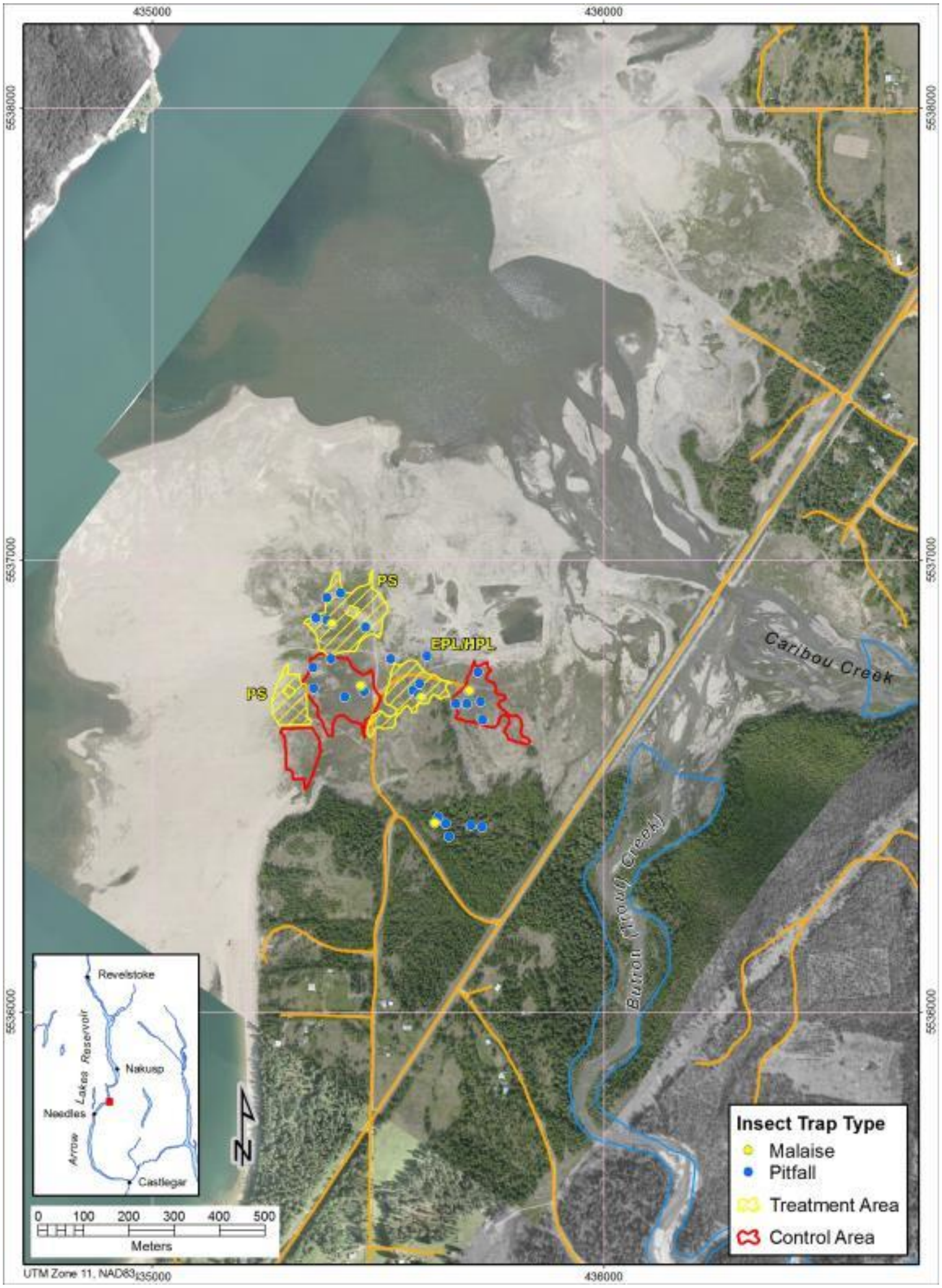
Map 10-1: Distribution of Malaise and pitfall traps installed at Beaton Arm, 2013



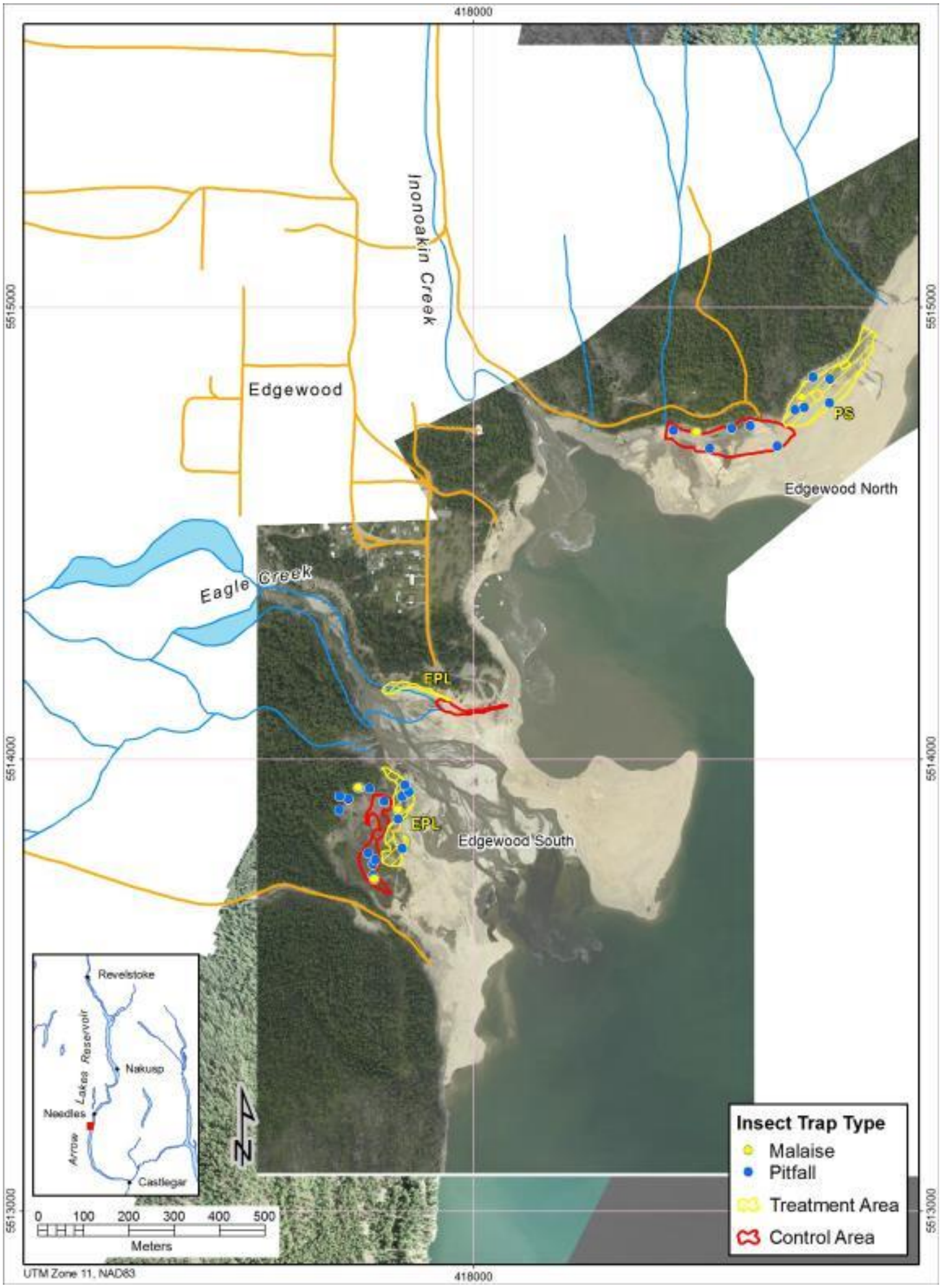
Map 10-2: **Distribution of Malaise and pitfall traps installed at East Arrow Park (south), 2013**



Map 10-3: Distribution of Malaise and pitfall traps installed at Mosquito Creek, 2013

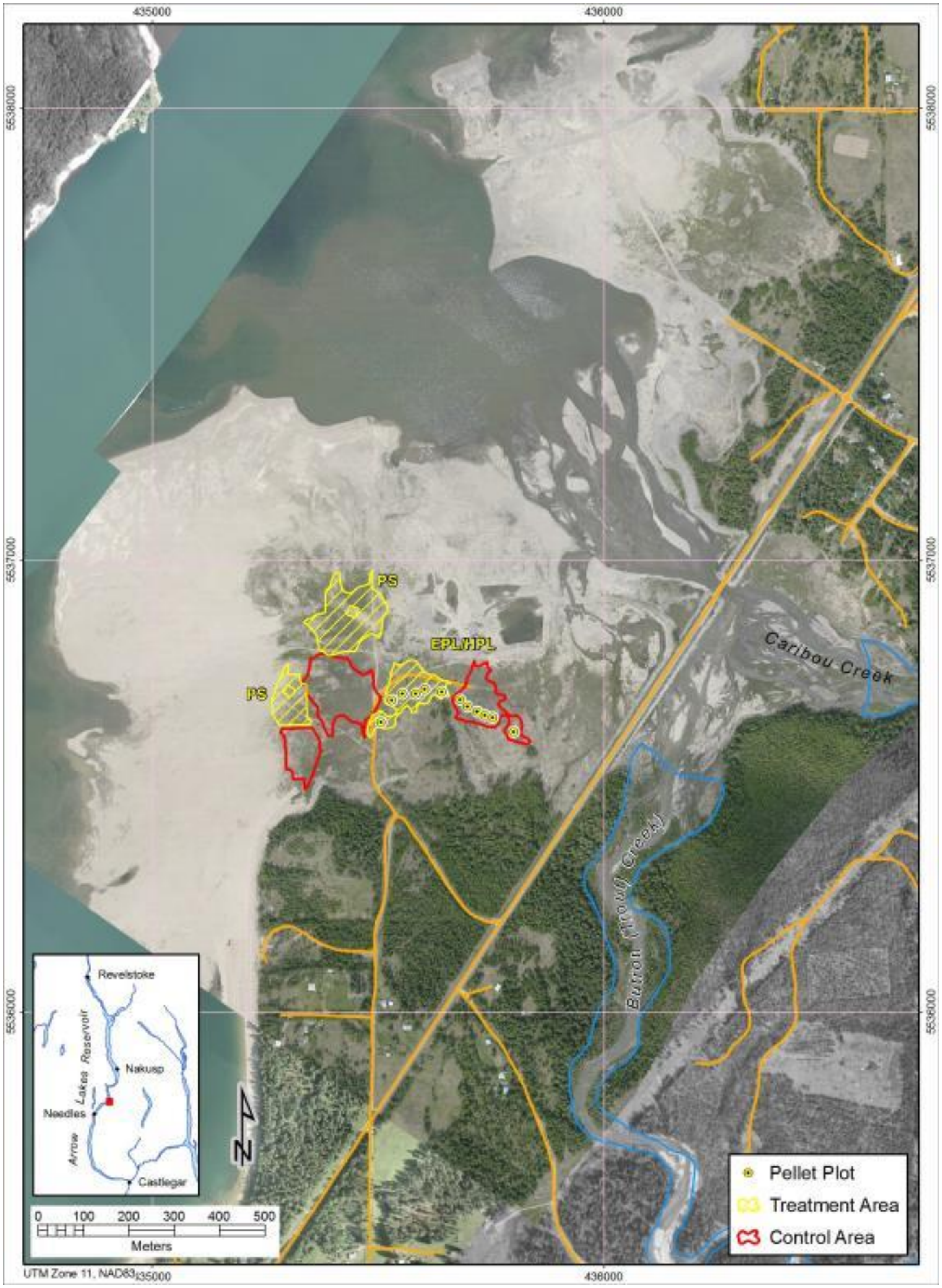


Map 10-4: **Distribution of Malaise and pitfall traps installed at Burton Creek, 2013**

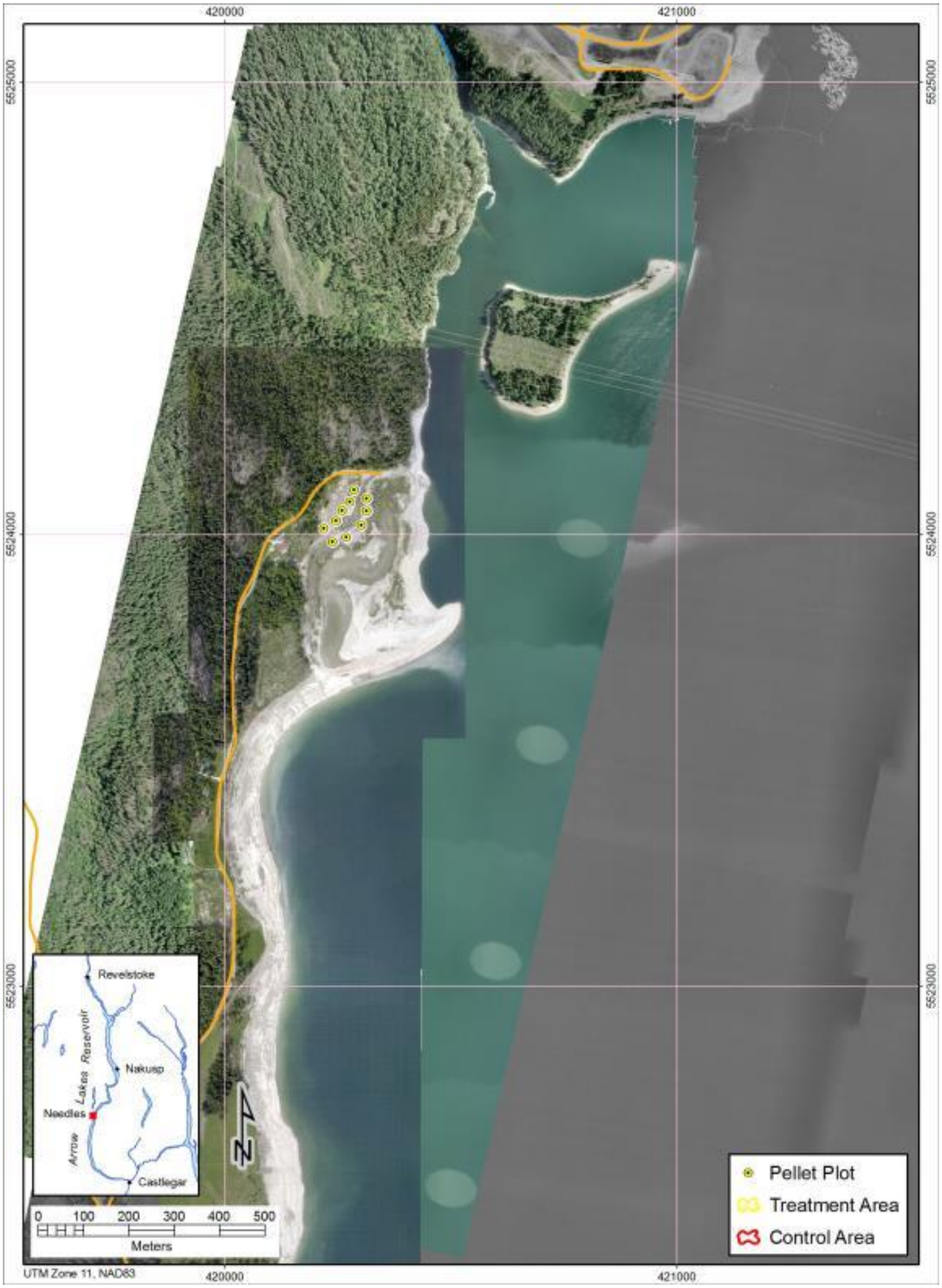


Map 10-5: **Distribution of Malaise and pitfall traps installed at Edgewood North and South, 2013**

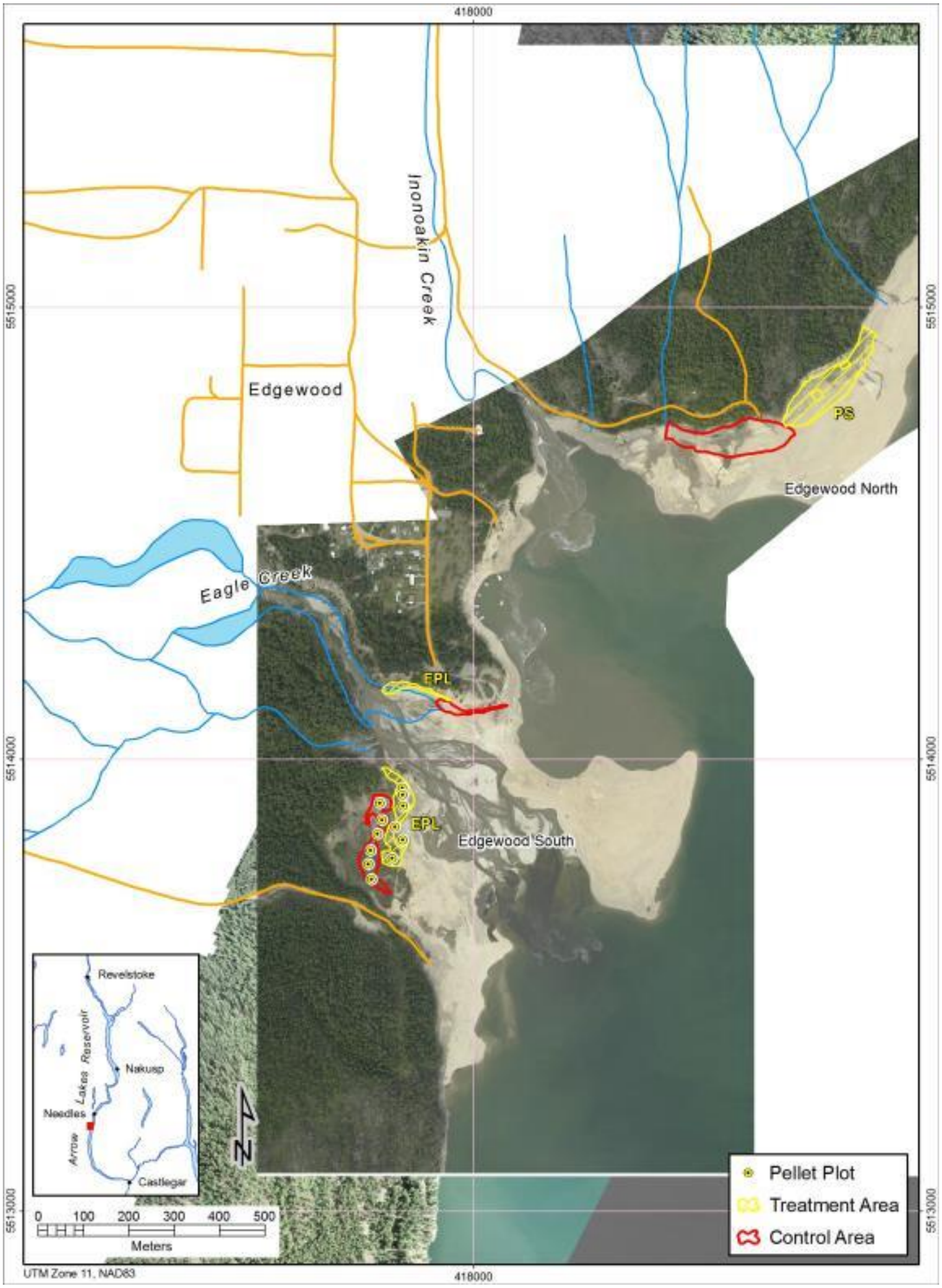
10.2 Appendix 10-B: Maps depicting the location of circular pellet plots sampled in 2013



Map 10-6: **Distribution of pellet plots sampled at Burton Creek**

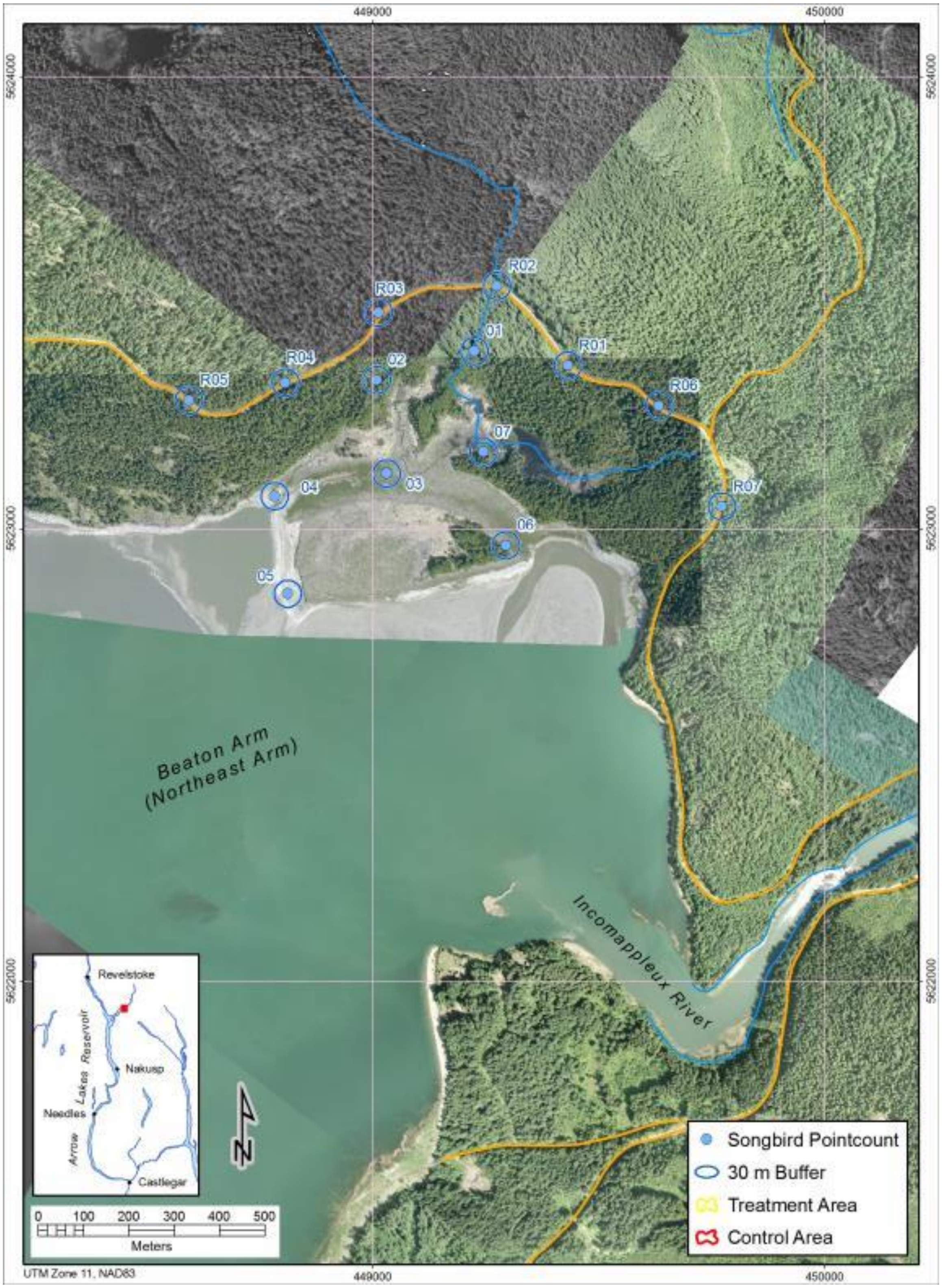


Map 10-7: Distribution of pellet plots sampled at Lower Inonoaklin Road



Map 10-8: Distribution of pellet plots sampled at Edgewood North and South

10.3 Appendix 10-C: Maps depicting the location of songbird point count stations for all reaches sampled in 2013

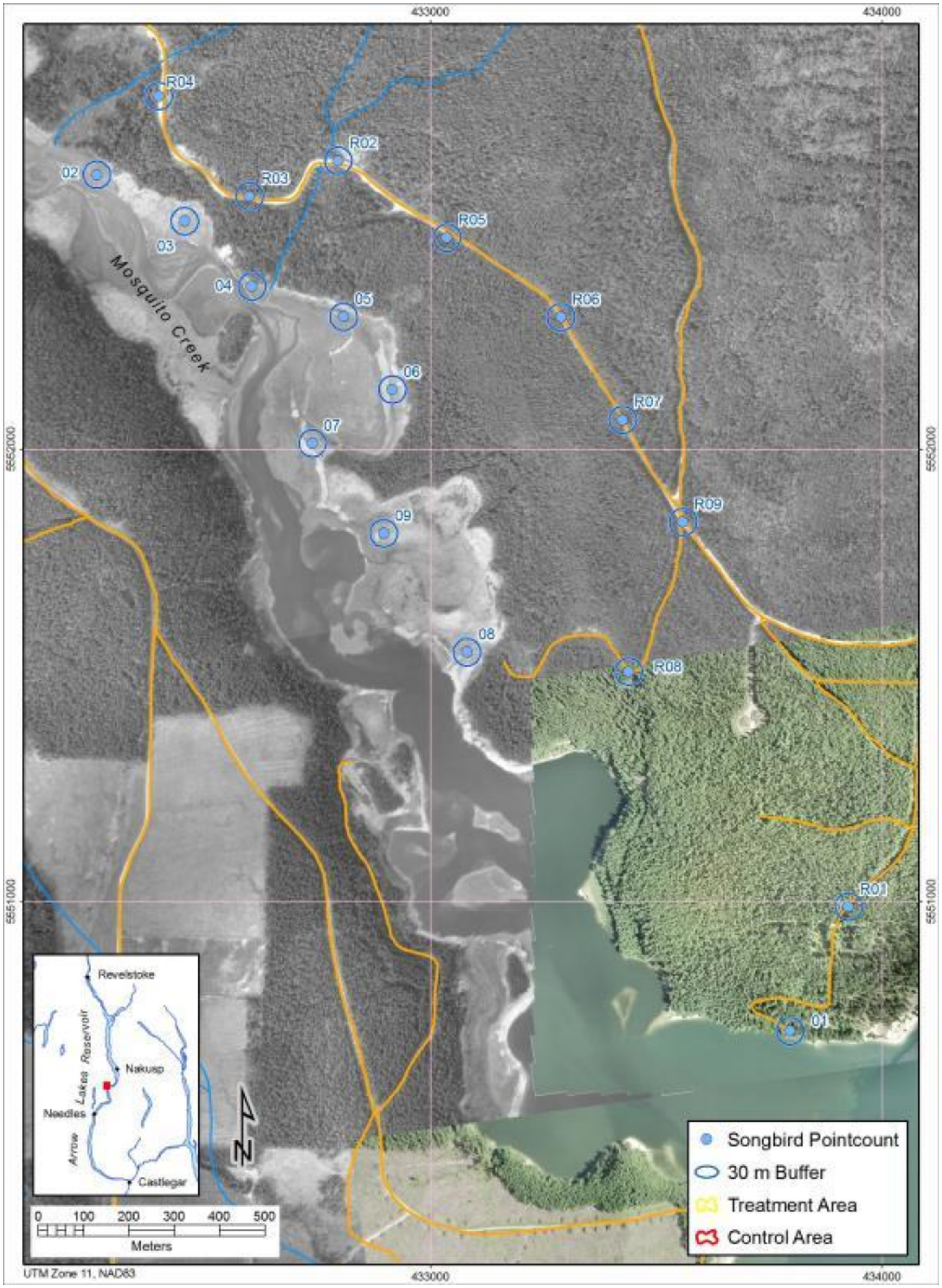


Map 10-9: **Distribution of songbird point count stations at Beaton Arm, 2013**

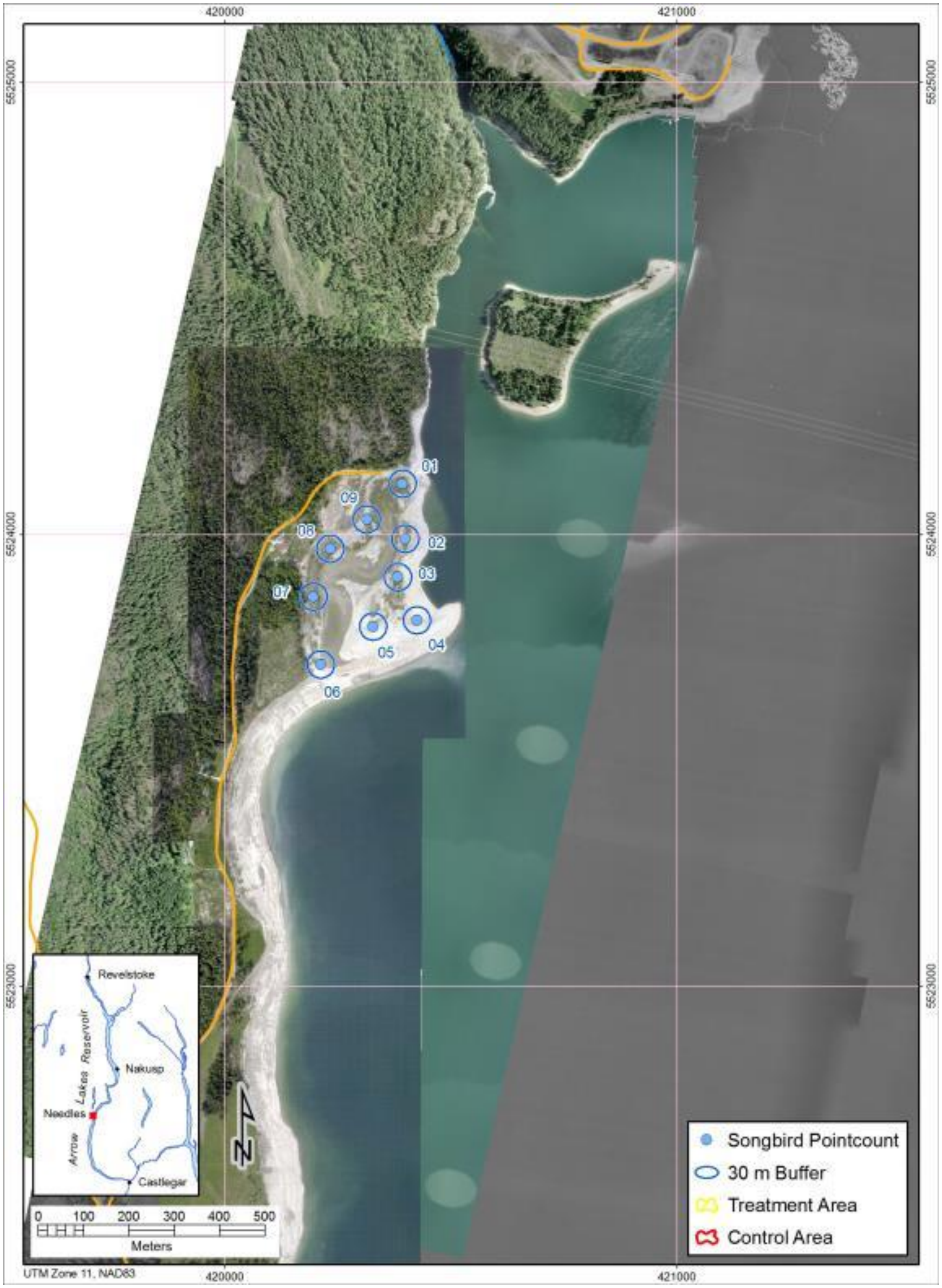
Map 10-10: **Distribution of songbird point count stations at Burton Creek, 2013**

Map 10-11: Distribution of songbird point count stations at East Arrow Park (north), 2013

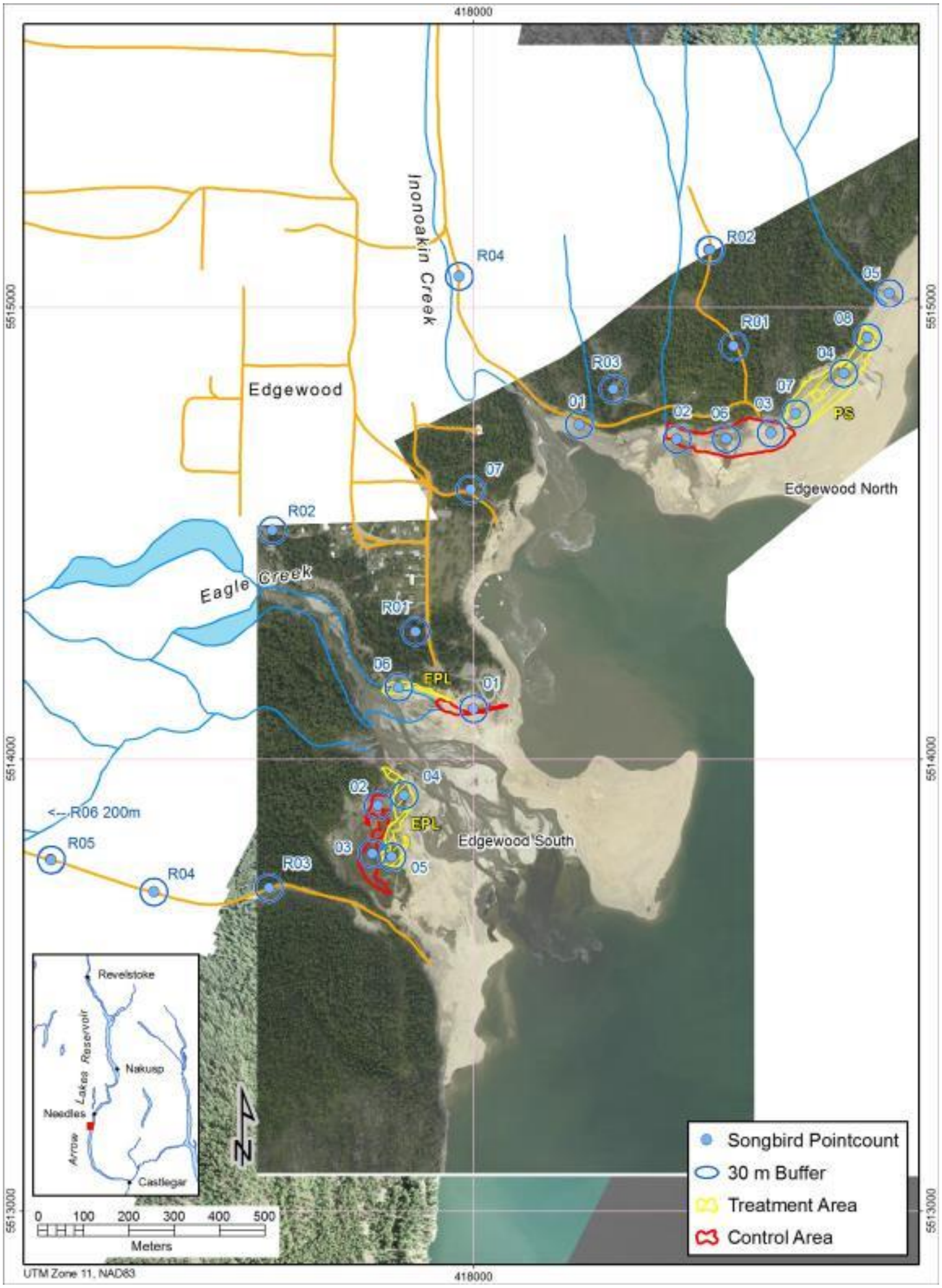
Map 10-12: Distribution of songbird point count stations at East Arrow Park (south), 2013



Map 10-13: Distribution of songbird point count stations at Mosquito Creek, 2013



Map 10-14: **Distribution of songbird point count stations at Lower Inonoaklin Road, 2013**



Map 10-15: Distribution of songbird point count stations at Edgewood (north and south), 2013

10.4 Appendix 10-D: Species of birds occurring at point count stations established in and adjacent to the drawdown zone of Arrow Lakes Reservoir in 2009, 2010, 2011 and 2013

Table 10-1: Species of songbirds, swifts, swallows, and hummingbirds documented from the drawdown zone and adjacent upland habitats in 2009, 2010, and 2011

		2009						2010						2011							2013						
Code	**Common Name**	**BE**	**BU**	**EA**	**EN**	**ES**	**MC**	**BE**	**BU**	**EA**	**EN**	**ES**	**MC**	**BE**	**BU**	**EA**	**EN**	**ES**	**LI**	**MC**	**BE**	**BU**	**EA**	**EN**	**ES**	**LI**	**MC**
ALFL	Alder Flycatcher													1													1
AMCR	American Crow		4	3			2		10	4	4	4		5	49	26	3	8	2	1	1	43	27		4	13	1
AMGO	American Goldfinch								1					1													
AMKE	American Kestrel								1			1				1				1					1	1	
AMPI	American Pipit							3	13	23	2	1	4	7	28	20	8	2	10	8	2	10	2	3			
AMRE	American Redstart	2	3	9	3	1	1	3	9	1			1	2		19	7		5	3	9	10	19	5	1	2	6
AMRO	American Robin	3	8	36	2	6	5	17	34	81	28	6	52	16	29	78	24	30	11	54	19	14	70	19	24	7	34
ATTW	American Three-toed Woodpecker						1											1		1					1		1
AMWI	American Wigeon							1			1					2		1	4	1			1	1		2	
BAEA	Bald Eagle	1	2		1	2	1	1	4	1	3	8	1		9	3		12	1	1	1	7	6	1	14		3
BKSW	Bank Swallow				1				1	4						8			4			2	2				
BASW	Barn Swallow		3	4		2		1	3	1	1	1		1	2	8			6		1						
BAGO	Barrow's Goldeneye	2											1				1										
BEKI	Belted Kingfisher		1					1				3		3	3	5	1	1		4	2	2			2	1	1
BLSW	Black Swift								5								1				5	1					
BCCH	Black-capped Chickadee		2	1	3		1	6	12	19	14	2	8	1	7	16	2	1	5	4	1	1	12		1		2
BHGR	Black-headed Grosbeak	4								1		1	1		1			1		1				1	2		
BWTE	Blue-winged Teal						1	1							1	1			2	1					1		
BRBL	Brewer's Blackbird					1																					
BRCR	Brown Creeper							1				3	4							2							2
BHCO	Brown-headed Cowbird			5					2	8	1	3	3		2	21	6	4	8	1			14		2		1
BUFF	Bufflehead										1		1	3	2	2	3	1	4	2	2		1	1		1	
BUOR	Bullock's Oriole		1	1											1	1			2	1							
CAGU	California Gull										1				2	2		1				2	1				

		2009						2010						2011							2013						
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CAHU	Calliope Hummingbird									1					1									2			1
CAGO	Canada Goose		3	4				2	7	15	5		7	8	16	37	7	4	11	22	10	11	26	7		5	8
CATE	Caspian Tern																1										
CAFI	Cassin's Finch	1																									
CAVI	Cassin's Vireo	4	2	4	1	2	5	7	3	12	2	1	8	16	2	20	6	5	2	12	11	2	8	6	9	3	21
CEDW	Cedar Waxwing		2	3			3	1	1	1		2			1	5		3	1	3	5	9	7	4	3	1	7
CBCH	Chestnut-backed Chickadee	2		1			2				2	9	7	11		10	2	9		12	2		1		4		10
CHSP	Chipping Sparrow	6	12	12	2	3	8	7	17	15	3	11	10	8	29	42	13	15	10	24	15	58	60	6	19	13	30
CITE	Cinnamon Teal																					1					
CLNU	Clark's Nutcracker															1											
CCSP	Clay-colored Sparrow								1							1											
CLSW	Cliff Swallow								1			1	1			1			5								
COGO	Common Goldeneye																									2	
COLO	Common Loon			1					1	2			1	5	4		5	2	2	4	1	10	8	1	5	2	
COME	Common Merganser		1	2			2	1	2	2			2		4	5	4	4		8		1	3	3	4		2
CONI	Common Nighthawk																					1					
CORA	Common Raven		3			1		2	10	5	3			4	14	24	6	7	11	8	3	18	10	12	7	4	9
COYE	Common Yellowthroat	9	1					10	2	4	3	5	2	9	1	25		5	7	9	18		12		8	18	2
DEJU	Dark-eyed Junco	2	1	2	2	3	3	17	20	15	6	8	12	8	6	1	2	9		14	8	6			3		13
DOWO	Downy Woodpecker		1	1						4																	
DUFL	Dusky Flycatcher				1	1				2					1	2				1					1		
EAKI	Eastern Kingbird		2			1				1		1			3	2		2	1				1				
ECDO	Eurasian Collared Dove															1											
EUWI	Eurasian Wigeon										1																
EUST	European Starling			4		1				3		2				12		3					12		1		
EVGR	Evening Grosbeak								1	1		3	1		1	7		5	2	7		5	7	1	15	3	5

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GADW	Gadwall														1								1			1	
GCKI	Golden-crowned Kinglet	6		1			2	17	13	14	9	5	11	6		4		3		5	11	3	10	4			1
GRCA	Gray Catbird		1	3	1						1				3	6			2				3			1	
GRJA	Gray Jay							2																			
GBHE	Great Blue heron, herodias subspecies	1																									
GHOW	Great Horned Owl										1																
GWFG	Greater White-fronted Goose											1															
GRYE	Greater Yellowlegs																			3							
GWTE	Green-winged Teal							1	1				2						2	2							1
HAWO	Hairy Woodpecker						2		1	2				3	1	2				1	3				2		5
HAFL	Hammond's Flycatcher	24	12	20	5	8	21	25	17	22	5	7	22	18	5	33	14	3	6	27	42	11	43	19	10	1	45
HADU	Harlequin Duck									1																	
HETH	Hermit Thrush	1												1										1			
HEGU	Herring Gull									1	1																
HOME	Hooded Merganser								1					2	1		3									1	
HOGR	Horned Grebe								1																		
HOLA	Horned Lark								1					1	1												
HOFI	House Finch								1																		
KILL	Killdeer	1	6	4	2	3	1	1		4	2	2	3		22	11	15	5	16	8			5	13	5	16	2
LALO	Lapland Longspur														2												
LAZB	Lazuli Bunting		3	2					1	2					5	2					1	14	16	2	1		8
LEFL	Least Flycatcher										1						1		2				1			7	
LESA	Least Sandpiper									1																	
LESC	Lesser Scaup																								1	1	
LISP	Lincoln's Sparrow						1	1						3		3		1	1	2							1
LBCU	Long-billed Curlew														2	1											

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LBDO	Long-billed Dowitcher																	1									
MACW	MacGillivray's Warbler	9		2	1	1	3	4	1	1	2		3	8	1	6	1	3	5	7	14	11	12	5	7		20
MGNW	Magnolia Warbler						1													1		2	2				
MALL	Mallard		2	3			5	3	1	6	1		3	3	5	7	2		3	12	5	3	16			5	6
MERL	Merlin								7	3	6	5			2	7		1				1	2				
MOBL	Mountain Bluebird								1	1		1			3					2		1	1				
MODO	Mourning Dove									1	1				1	1	1						1	2	1		
NAWA	Nashville Warbler				5	1	1			11	14	4				1	13	1	5	2			1	15	2	1	2
NOFL	Northern Flicker	1		1		2			10	7	2	3	2	1	11	26		7	6	11	1	5	12	3	5	1	14
NOGO	Northern Goshawk						2													2							
NOHA	Northern Harrier								1																		
NRWS	Northern Rough-winged Swallow	5	9	2	3	1	3	1	7	18	2	1	10	3	25	10	13	1	24	16	1	3	1	2		7	3
NOSL	Northern Shoveler										1				1	1	1	1	1					1		1	
NOWA	Northern Waterthrush				1																						
OCWA	Orange-crowned Warbler							1	2	4		2		1	1	4	1	1		4	2						
OSPR	Osprey		3	1				1	3	2		1	2	6	11	9	5	1	2	3	4	9	4	3	2		8
PALO	Pacific Loon														1												
PAWR	Pacific Wren					1		9	4	5	4	3	10	12				10		7	26	1	2	2	11		10
PSFL	Pacific-slope Flycatcher	1	2														1					1		2		3	
PIWO	Pileated Woodpecker	1	1					1		1				9	3	7		4		5	7		1	1	3		4
PISI	Pine Siskin	1		9	1		2	17	3	14	1	2	16	33	4	37	7	11	5	37	4	12	16	6	10	2	14
RECR	Red Crossbill			1				1	3		1	1	7	22	7	8	5	8	2	20	2						
RBNU	Red-breasted Nuthatch	4	8	5	1	3	5	17	20	17	20	9	8	25	19	24	16	14	10	24	7	13	5	11	7	5	5
REVI	Red-eyed Vireo	1	7	5	2	2	3	2	6	2	3		1		6	8	6	2	2	2	13	55	24	14	9	7	16
REDH	Redhead																									1	
RNSA	Red-naped Sapsucker	3	1	2		1		6		11	4	1	11	23	5	8		2	5	9	12	1	2		3	3	4

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RNGR	Red-necked Grebe																		1								
RTHA	Red-tailed Hawk		2							1							1		4	1			1				1
RWBL	Red-winged Blackbird									2			1	2		5		2		1							
RBGU	Ring-billed Gull		1						1					1	7			2					1				
RNDU	Ring-necked Duck										1							1						1	1	1	
RCKI	Ruby-crowned Kinglet							1	3		8	1	5	9	1	4		2		5							
RUGR	Ruffed Grouse	1		1				4	9	4	5		3	10	7	4				10	4	6					2
RUHU	Rufous Hummingbird	2		3		2		3	3	12	1	4			2	5	1	8		2		2	4	3	4		2
SAVS	Savannah Sparrow		1	1				2	22	13	3	6	2	2	18	4	3	8	6	3		9		1	1	1	
SSHA	Sharp-shinned Hawk									1					1			1									
SOSA	Solitary Sandpiper												1							1							
SOSP	Song Sparrow	4	1	5			1	7		8	2		7	12		3			4	12	5		9			1	15
SPSA	Spotted Sandpiper	4	6	8	1		7	1	1	1	2	1	3	8	14	18	6	2	10	18	1	18	10	9	6	8	14
SPTO	Spotted Towhee										1						1										
STJA	Steller's Jay							3		5			2	1	1	7		6			1						1
SWTH	Swainson's Thrush	9	2	6	1	3	13	5	4	1		1	3	13	1	8	3	7		12	24	22	15	7	15	3	17
SWSP	Swamp Sparrow													1													
TOSO	Townsend's Solitaire										1						1										
TOWA	Townsend's Warbler					3		5		5		7	4	5	1		3	21				3	1		35	1	
TRSW	Tree Swallow	5	10	9	1	1	1	1	3	14	4	4	1	3	13	39	4	4	21	1	5	1	7		6	9	
TUVU	Turkey Vulture					1			1	1	2				2	1	1	1				5			1		
VATH	Varied Thrush	5		1				8	2	10	5	3	5	19	3	7	1	1	1	12	15	1	1		2		1
VASW	Vaux's Swift	2	1	1				7	1	5	2	2	1	2	1	4	2	4			2	4			2		
VEER	Veery			1			1						1						2	1						3	
VGSW	Violet-green Swallow		2	10	3	1			1	16	3	5	2		7	25	6	4	20	1		2	14	4	4	4	
WAVI	Warbling Vireo	8	2	11	3	1	4	3		10	4	2	3	8	1	15	9	1	1	1	10	8	24	6	7	1	14

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WEGR	Western Grebe										1						3				1			3	3		
WEKI	Western Kingbird									2					2					1							
WEME	Western Meadowlark		3	1					24	10	1				4	21						20	51				1
WETA	Western Tanager	1	2	2	1		2	5	1	5	1	1	1	5	4	12	5	5	3	5	8	6	14	4	8	4	9
WWPE	Western Wood-Pewee	1		1	1			1	3	3	1	2	3	2	4	3	2		3	2	1	16			1	2	2
WCSP	White-crowned Sparrow								1		1	1	2					3								1	1
WTSP	White-throated Sparrow																	1									
WWCR	White-winged Crossbill							1																			
WIFL	Willow Flycatcher	3	3	1				1						2		2			1		12		2			12	1
WIPH	Wilson's Phalarope																									2	
WISN	Wilson's Snipe												1	1							1						1
WIWA	Wilson's Warbler	1	2					1	3		1	1	5		2	3	1	4			4	3	2	1	1	3	
WODU	Wood Duck								2												1						
YEWA	Yellow Warbler	2	2	4	1	2		1	1	5	4	3	1	3	2	7	6	4	7	1	6	5	9		1	8	2
YHBL	Yellow-headed Blackbird								1							4											
YRWA	Yellow-rumped Warbler	5	12	9	6	3	4	16	42	67	28	12	40	27	50	42	29	12	6	45	20	43	43	15	10	1	33