Columbia River Project Water Use Plan

KINBASKET AND ARROW LAKES RESERVOIRS

Reference: CLBMON 11B-2

Arrow Lakes Reservoir
Revelstoke Reach Spring Songbird Effectiveness Monitoring

Study Period: Year 3 - 2011

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CLBMON 11B-2: Revelstoke Reach Spring Songbird Effectiveness Monitoring

Year 3 - 2011

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Cover photo: Revelstoke Reach, Arrow Lakes Reservoir, B.C., migrating Northern Shrike (*Lanius excubitor*) in the drawdown zone. Photo by Harry van Oort

EXECUTIVE SUMMARY

In 2009, BC Hydro initiated an effectiveness monitoring study (CLBMON 11B) in the Arrow Lakes Reservoir. CLBMON 11B monitors a diversity of terrestrial taxa and habitat in relation to revegetation and wildlife enhancement activities. A component of that study, CLBMON 11B-2 (this study), is concerned with effectiveness monitoring of physical works in Revelstoke Reach with respect to spring migrant songbirds. This report outlines results from Year 3 (2011) and some preliminary analyses of the data.

Field data were collected for seven weeks from late April to early June 2011. Effectiveness monitoring data were collected repeatedly at fixed monitoring plots, once per week, throughout the monitoring period. Wildlife Physical Works (WPW) projects will not be initiated until 2012, but sampling was conducted at two sites in order to document habitat use prior to WPW habitat manipulation. Near Machete Island, we monitored songbird abundance and diversity at the erosion channel at the WPW6A site. Weekly encounter transect sampling was conducted along the shoreline of the Cartier Bay wetland, a site that will be modified by both WPW15A and WPW14. Two existing Revegetation Physical Works (RPW) treatments were monitored in 2011. We monitored one large site where water sedge plugs had been planted in 2010. We also monitored multiple treated and untreated (control) sites to determine the effectiveness of cottonwood stake treatments. Sampling at randomly selected sites was also conducted throughout the field season to determine habitat selection by migrating songbirds.

WPW6A is designed to halt erosion in an eroding channel to protect wetland habitat upstream of the channel. At the erosion channel, we observed 186 birds (seven species) from four permanent plots sampled every week (28 sampling occasions): 55 birds were recorded within plots, with 42 in the footprint area, including a group of 40 American Pipits observed on one occasion. The results to date suggest that WPW6A is unlikely to have significant negative effects on migrating songbirds due to habitat manipulation at the construction site; however, results from random sampling support the importance of proceeding with this project because the upstream wetlands being protected from drainage were used extensively by migrating songbirds.

Data from the weekly encounter transects along the largest stretch of Cartier Bay shoreline to be impacted by WPW 14 and 15A provided evidence that shorelines may be selected by some migrating songbirds. A total of 997 birds was detected from two species: American Pipit (99% of detections) and Savannah Sparrow. The results indicated that the shoreline habitat of Cartier Bay in its unaltered state was selected by American Pipits. These data were not affected by reservoir operations in 2011, which only impacted the site after the pipit migration had ended.

It is too early to know if the any of the revegetation treatments will influence use of the site by migrating songbirds. However, in Year 3, the cottonwood stakes were providing perching and foraging opportunities for migrating birds, and the 2011 data showed evidence that migrating songbirds may have been selecting treated plots over control plots. Each week, the average number and diversity of migrating songbirds detected on-plot was slightly higher at treated sites compared with control sites. Yellow-rumped Warblers were the most commonly detected species at cottonwood revegetation sites, comprising 60% of the on-plot detections. It was unclear in 2011 if the water sedge plug treatment at 9 Mile was successful, as a large natural sedge component in the area obscured the planted sedge plugs.

We sampled 71 random plots in 2011, with a representation from each of the five habitat strata. Shrub and tree habitat strata typically were used more than unvegetated and

grassland plots; wetland habitats received intermediate levels of use. Some preliminary binary habitat selection models were run on the three-year data set. These suggested that tall shrub cover is selected and that open habitat is avoided, but they did not provide much evidence that the species of shrub was important.

This is the last year that spring migration monitoring in Revelstoke Reach will be conducted under the umbrella of CLBMON 11B. In future, spring migration monitoring in Revelstoke Reach will continue as part of the CLBMON 39 project, which will monitor songbird migrations in both spring and fall. Regarding effectiveness monitoring of physical works, we recommend that the cottonwood stake monitoring continues annually, and that monitoring at Cartier Bay is repeated until an equal monitoring effort has been realized before and after the WPW15A is completed.

KEYWORDS

Spring migrant songbird, habitat use, effectiveness monitoring, Revelstoke, British Columbia, Arrow Lakes Reservoir, BC Hydro, reservoir operations

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Field studies were completed by Cooper Beauchesne and Associates Ltd. (CBA) biologists Jen Greenwood, Devon Anderson, Michal Pavlik, Ryan Gill, and Harry van Oort. Ryan Gill provided GIS support throughout the study. Jen Greenwood, Len Edwards, Ryan Gill, and Harry van Oort collected additional habitat data. Harry van Oort provided overall supervision of study design development and field surveys. John Cooper acted as Project Manager. Suzanne Beauchesne (CBA) provided an internal scientific review of the report. A technical edit of the draft report was provided by Tracey Hooper. Doug Adama and Ed Hill's comments greatly improved the quality of this report. CBA is grateful for the contributions made by everyone mentioned above.

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1 INTRODUCTION

Riparian habitats in British Columbia and North America have been disproportionately degraded or destroyed by human activities (Campbell et al. 2001, Noss et al. 2001). The Columbia River system in Canada and the U.S. is one of the more degraded river systems in the world, with numerous dams constructed over the last century (Nilsson et al. 2005). Dams and reservoir operations have played a significant role in the estimated loss of 87% of high wildlife-value riparian habitat within the Columbia Basin (Moody et al. 2006, Utzig and Schmidt 2011). In British Columbia, about one-half of forest-dwelling terrestrial vertebrate species use riparian habitats during at least one life history stage (Bunnell et al. 1999). Many migratory songbirds follow valleys during their annual migrations, and find food and cover in riparian vegetation along the way (Wiebe and Martin 1998, Skagen et al. 2005a, 2005b).

In the Canadian portion of the Columbia Basin that lies between the Hugh Keenleyside Dam and the north end of Kinbasket Reservoir (~450 km in length), most of the valley bottom riparian habitat has been lost due to the creation of reservoirs (Moody et al. 2006, Utzig and Schmidt 2011). Today, migratory bird populations that travel along the Arrow Lakes Reservoir encounter very few sites where extensive tracts of riparian valley bottom vegetation exist. Revelstoke Reach (Section 1.4 below) provides a significant amount of riparian habitat, and may be one of the most important stopover sites along this route. Accordingly, there are significant movements of migrating songbirds through the area each spring and fall (Jarvis and Woods 2002, CBA 2009a, 2009b, 2010a, 2010b, 2011a).

The availability and quality of riparian habitat in Revelstoke Reach is heavily dependent on reservoir operations. Because conditions at migratory stopover sites can affect bird populations (Newton 2006), stewardship of Revelstoke Reach should consider the life requisite needs of migratory songbirds during this vulnerable time of their life cycle. As such, management of habitat for migrating birds was identified as a priority by the Water Use Planning Consultative Committee for the Columbia River. Current initiatives to manage habitat in the drawdown zone of Revelstoke Reach include revegetation physical works (RPW) projects (e.g., CLBWORKS 2), wildlife physical works (WPW) projects (e.g., CLBWORKS 30), and the Arrow Soft Constraints on reservoir operations. These projects vary in scope from the planting of sedge seedlings to the construction of dykes for managing wetlands.

In 2009, BC Hydro launched several effectiveness monitoring projects in the Arrow Lakes Reservoir. CLBMON 11B monitors a diversity of terrestrial taxa (including migratory songbirds) as well as wetland and riparian habitat, in the lower and upper sections of the Arrow Lakes Reservoir. The study reported here (CLBMON 11B-2) was initiated as a separate component of CLBMON 11B in 2009. It is concerned only with effectiveness monitoring of the planned RPW and WPW projects in Revelstoke Reach, and its scope is restricted to migrating songbirds during the spring migration. In future years, spring migration monitoring in Revelstoke Reach will continue as part of the CLBMON 39 project, which will monitor songbird migrations in both spring and fall.

1.1 Scope and Objectives

The objectives for all CLBMON 11B monitoring programs are to:

- Develop a monitoring program to assess the effectiveness of the revegetation program (CLBWORKS-2) and wildlife physical works projects (CLBWORKS-30) at enhancing wildlife habitat in the drawdown zone of Arrow Lakes Reservoir.
- Monitor the appropriate biological indicators and response variables to assess the effectiveness of the revegetation and wildlife physical works programs at enhancing wildlife habitat in the drawdown zone.
- Provide recommendations on the effectiveness of the revegetation program and wildlife physical works projects on improving habitat for wildlife in the drawdown zone.

The intent is to use this information to inform and improve enhancement techniques over time.

1.2 Management Questions

The management questions specified for CLBMON 11B are as follows:

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

If so,

- To what extent does the revegetation program and the wildlife physical works projects increase the productivity of habitat in the drawdown zone for wildlife?
- Are some methods or techniques more effective than others at enhancing wildlife habitat in the drawdown zone?

1.3 Management Hypotheses

The management hypotheses stated for CLBMON 11B are as follows:

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 herptiles 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 herptiles, 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 herptiles 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 herptiles, 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 vegetation 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 CLBMON 11B-2 monitoring program will address only a subset of the CLBMON 11B management hypotheses—those that can be tested with studies of migrating songbirds in Revelstoke Reach (HA_1, HA_{1A}, HA_{1B}, H_2, HA_{2A}, HA_{2B}, HA_3, HA_{3A}, and HA_{3B}). The manner in which the relevant management hypotheses are related to the management questions and objectives is reviewed in Appendix 6-1.

1.4 Study Area

The study area is defined as the drawdown zone of Revelstoke Reach—the northernmost arm of the Arrow Lakes Reservoir (Figure 1-1). The Revelstoke Reach is described in detail below.

Arrow Lakes Reservoir is operated by BC Hydro, and is licensed to operate between 420 and 440.1 m elevation above sea level (asl) under constraints imposed by the Columbia River Treaty. Reservoir level is maintained through precipitation (snow and rain), discharge from Mica and Revelstoke Dams, and outflow from Hugh Keenleyside Dam. The reservoir is operated by BC Hydro to store water in spring and summer (and sometimes in the fall), and to draw down water elevations in late summer through winter (Figure 1-2).

The study area lies within the Interior Cedar Hemlock biogeoclimatic zone (ICHmw2, ICHmw3) of British Columbia (Meidinger and Pojar 1991). This region typically receives much of its precipitation from Pacific frontal systems in the form of snowfall during the winter. The slopes above the reservoir's drawdown zone are dominated by managed coniferous forests.

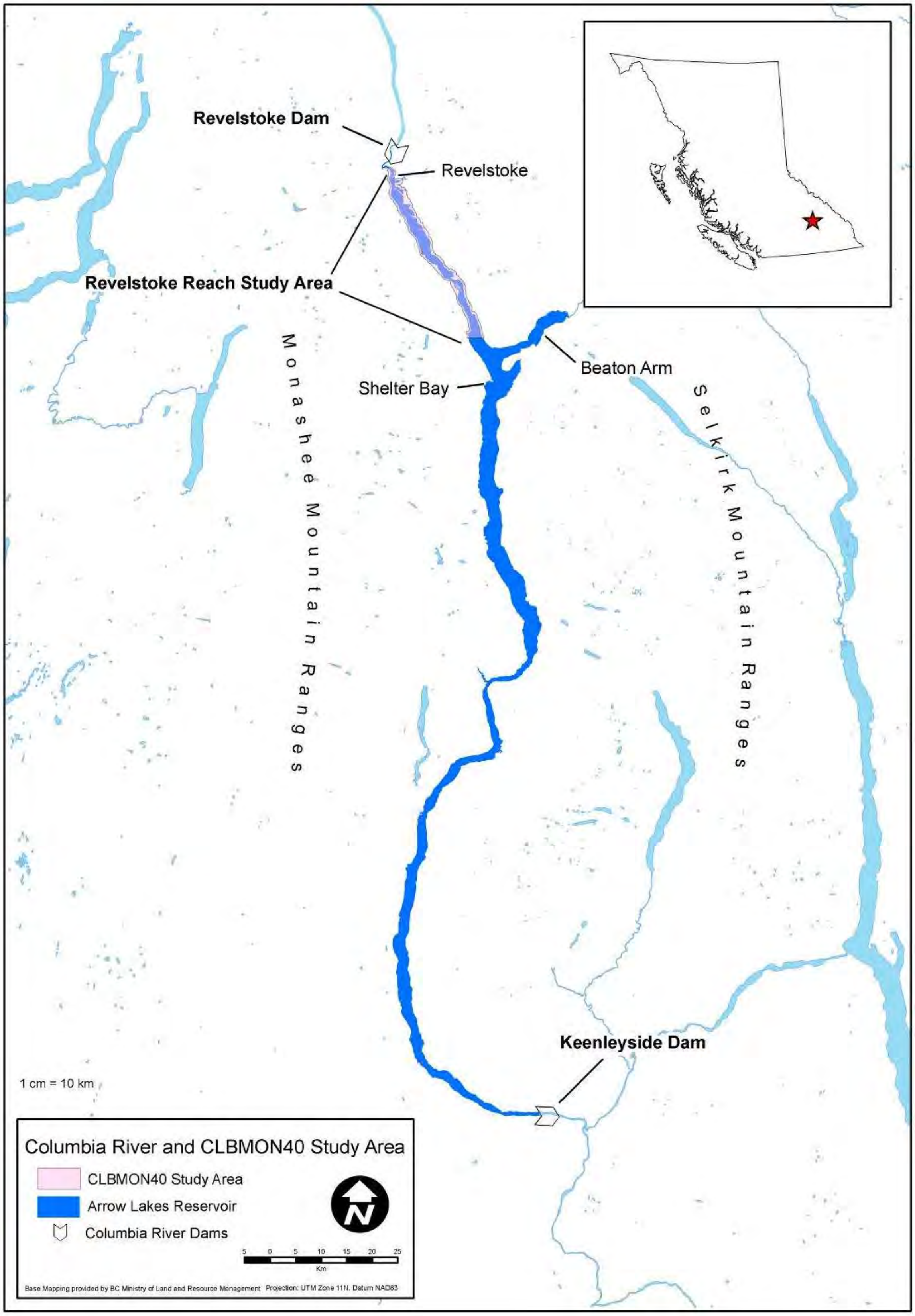

Figure 1-1: Location of the study area (Revelstoke Reach)

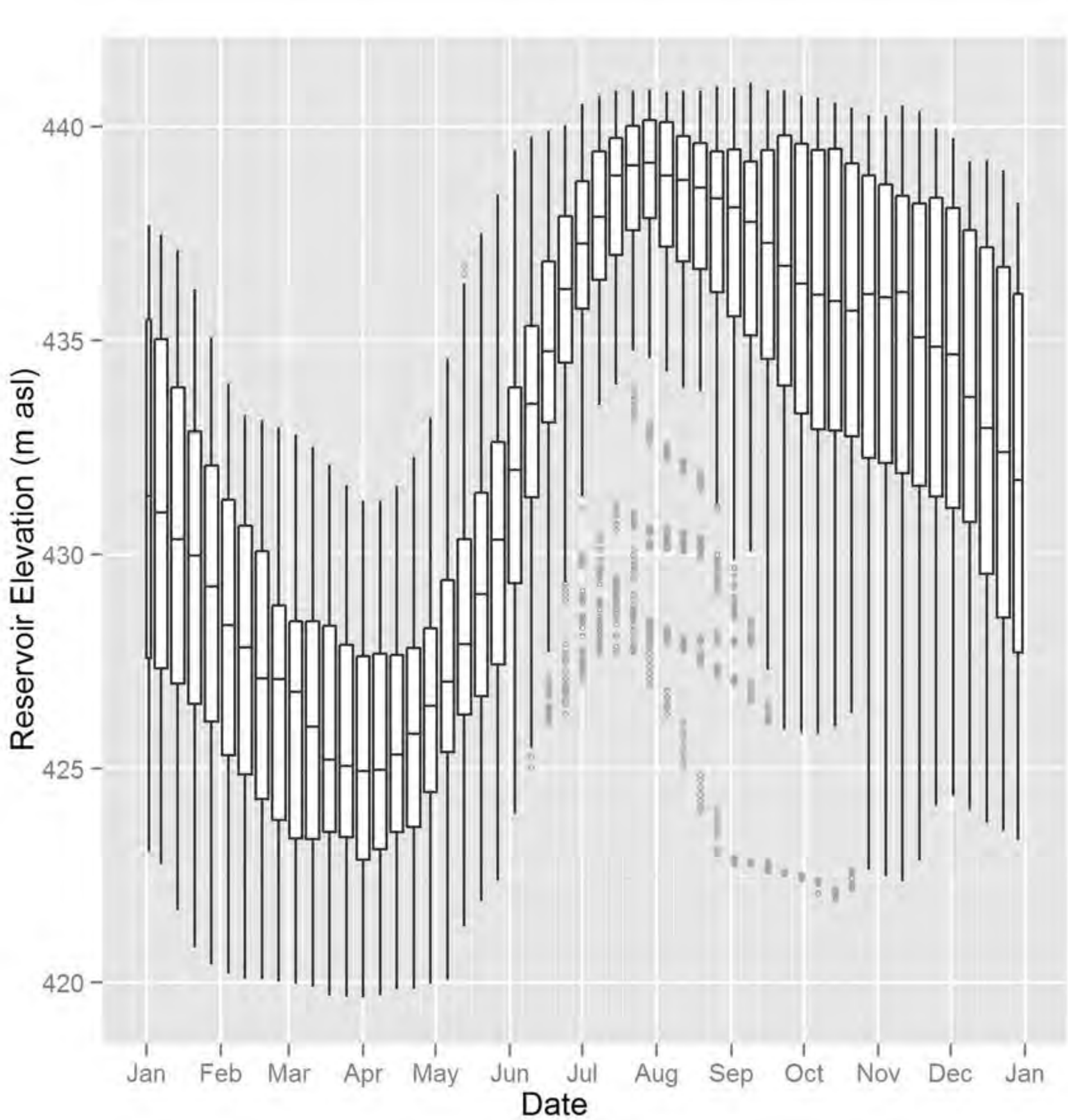

Figure 1-2: **Box plots showing historic reservoir elevations in weekly intervals (data range = April 1, 1968 to March 31, 2011); outliers are plotted in grey**

Revelstoke Reach contains the Columbia River as it flows south from the Revelstoke Dam towards the Arrow Lakes Reservoir, and is flooded by the reservoir for a variable portion of the year. The Revelstoke Reach drawdown zone includes most of the level valley bottom habitat in the area. These flats are comprised of a sandy-soiled floodplain with subtle topography that is shaped by the erosion and deposition of material from the Columbia River, and includes an oxbow lake, old back channels, and sand bars. Historically, this area was naturally forested by western redcedar (*Thuja plicata*), Engelmann spruce (*Picea engelmannii*), and black cottonwood (*Populus balsamifera*). Prior to the completion of Hugh Keenleyside Dam near Castlegar (fall 1968), much of the riparian forests along the Revelstoke Reach valley bottom had been cleared, and the area was used extensively for farming and ranching. In many places, the old roads and railway grades remain prominent features of the Revelstoke Reach drawdown zone habitats.

Today, the flats are vegetated extensively by reed canarygrass (*Phalaris arundinacea*) and sedges (*Carex* spp.), and to a lesser degree by horsetail (*Equisetum* spp.) above 432 m elevation (Korman 2002). Willow shrubs (typically *Salix sitchensis*) and sapling cottonwood (*P. balsamifera*) become increasingly established above 437 m in the upper elevations of the drawdown zone. Mature cottonwood riparian forest habitat can be found in a few locations above 439 m elevation.

1.5 Wildlife Physical Works Projects

More than 40 wildlife physical works projects were initially identified in the Columbia Water Use Plan (BC Hydro 2005). Those proposals were reviewed for feasibility in 2008 (Golder Associates 2009a), and five projects were selected for detailed consideration (Golder Associates 2009b). In 2010, plans were completed for implementing three WPW projects: WPW6A, WPW14, and WPW15A. These three projects have become the emphasis of the CBA wildlife physical works monitoring to date. WPW14 and WPW15A will be monitored together due to their similarity, proximity, and connectedness. Additional projects will be considered for implementation in future years.

1.5.1 WPW6A

The goal of WPW6A is to prevent an erosion channel (Figure 1-3) from cutting further towards the Airport Marsh. A gravel blanket and rip-rap will be installed to reinforce the eastern branch of the erosion channel as a trial to see if erosion can be halted. The net effect of this project will be to protect the habitats upstream (i.e., Airport Marsh) from further erosion. However, the habitat modifications made at the site of the erosion channel—the addition of the rock reinforcement and revegetation —may have an impact on migrating songbirds either by destroying favoured habitat or by increasing the site's habitat value. Both the work site and the habitats to be protected are being monitored.

1.5.2 WPW14 and WPW15A

These projects are both planned at the oxbow lake at Cartier Bay. The common goal of these projects is to create additional shallow pond habitat (less than 1 m deep) and to protect the existing wetlands by reinforcing parts of the retaining structures that might fail (Golder Associates 2009a, 2009b, 2009c). This pond's water is partially retained by an old railbed, but there are two breaches in this structure (Figure 1-4), and the primary task is to repair these. WPW14 involves repairing the northern breach in the old rail bed, which will back-flood approximately 6 ha, thereby creating additional shallow water habitat. WPW15A involves removing an old collapsed box culvert at the southern breach, and rebuilding and fortifying the rail bed. The dike will be elevated approximately 1 m to create an additional 26 ha of shallow water habitat that is less than 1 m deep. This will also reduce the frequency, magnitude, and duration of inundation during high reservoir levels. These projects will increase the capture of spring runoff and retain water from the reservoir as it recedes.

These projects are intended to improve habitat for amphibians, waterfowl and other aquatic wildlife at Cartier Bay, but it is unknown if the terrestrial habitats that will be impounded are important for migrating songbirds during spring migration.

Figure 1-3: **Collapsing erosion channel that will be fortified with a gravel blanket and rip-rap by WPW6A. Initially, the east branch will be treated as a trial to assess its effectiveness at preventing erosion**

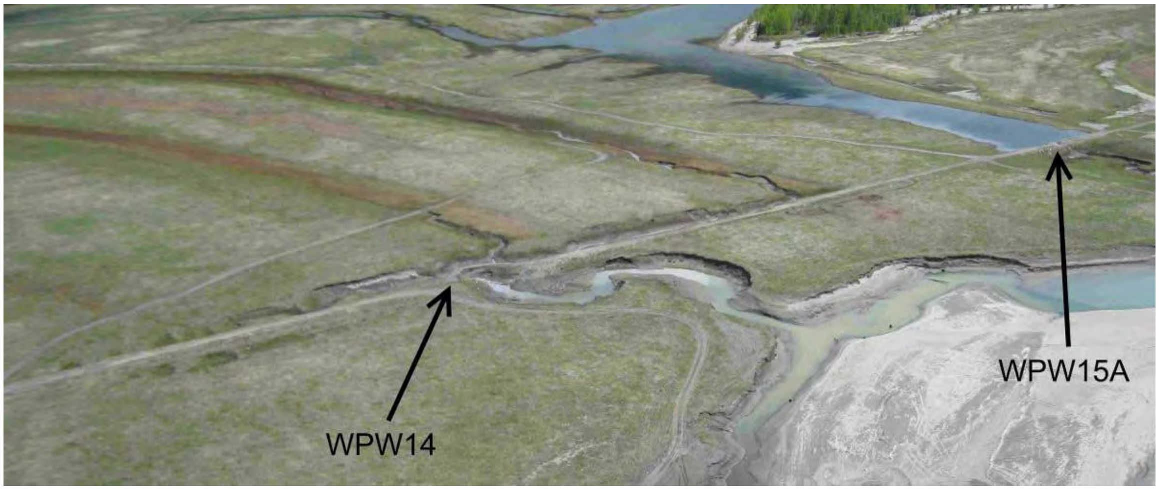

Figure 1-4: **Sites where WPW14 and WPW15A will repair breaches in the old Canadian Pacific Railway Arrowhead Branch rail grade to modify and protect the Cartier Bay wetland**

1.6 Revegetation Physical Works Projects

CLBWORKS-2 is a revegetation program in the Arrow Lakes Reservoir, with planting carried out in 2009, 2010, and 2011. These treatments involved the planting of mixed sedge plugs, water sedge plugs, and cottonwood stakes. Although the revegetation treatments were not specifically designed for songbirds, it is expected that revegetation (especially using the cottonwood stakes) may provide nesting habitat for songbirds

(Keefer et al. 2009, Keefer and Moody 2010b), and potentially provide foraging habitat for migrating songbirds. Various shrub species (willow and dogwood) were occasionally planted alongside the cottonwoods, but these treatments were not extensive enough to be monitored.

1.6.1 Mixed Sedge Plugs

Mixed sedge plugs were grown from seed in a greenhouse and were planted as young seedling plugs. The plots were planted primarily with two species, *C. lenticularis* and *C. aperta,* which were planted at approximate densities of 10,000–14,000 plugs per hectare at elevations between 434 and 438 m (Keefer et al. 2009). Mixed sedge plugs were planted at many sites over an extensive area in the fall of 2009 (Keefer et al. 2009). These treatments were monitored in 2010 (CBA 2010a); however, it was evident in 2011 that the plugs suffered considerable mortality. Because the sedge planting was unsuccessful, CBA discontinued monitoring this treatment.

1.6.2 Water Sedge Plugs

Water sedge (*C. aquatilus*) plugs were grown in a greenhouse from seed and were planted as young seedling plugs at elevations between 434 and 435.99 m (Keefer and Moody 2010a). Water sedge plugs were planted extensively at one site at 9 Mile at approximate densities of 4,000 plugs per hectare (Randy Moody, pers. comm.). The site consisted of a sloping draw that was already vegetated by grasses and mixed sedges. Water sedge is a large, robust species that is found in fens and other wetlands, and can grow to be 120 cm tall; however, during the 2010 monitoring season, the plugs were less than 10 cm tall and were hidden by the existing vegetation. In 2011, we were unable to reliably identify the planted sedges from the pre-existing ones, which made the cost/benefit of this effectiveness monitoring study uncertain. Monitoring was continued because we could not be certain that the treatment had failed.

1.6.3 Cottonwood Stakes

Cottonwood stakes were harvested locally and were planted in the spring of 2010 and 2011. The second planting of stakes was conducted mainly in the 9 Mile area. The stakes were approximately 1.5–2 m in length and 5–15 cm in diameter (Figure 1-5). Larger stakes were planted with the aid of a small excavator; smaller stakes were hand planted.

This treatment was implemented extensively in several areas, at elevations greater than 438 m (Figure 1-5). Prior to treatment, most sites contained no shrubs or trees, but some had very low densities of willows or sapling cottonwoods. When planting the cottonwood stakes, areas with prolific natural sedge communities were avoided, and the stakes were typically planted where reed canary grass was the dominant ground cover (Keefer and Moody 2010a). The success of this treatment could potentially result in dense riparian forest habitat that would provide habitat for migrating and nesting songbirds.

The treatment protocol in 2010 was to plant the stakes at least 1.5 m apart; average spacing was 2 m (Keefer and Moody 2010a). Initial reports suggest that the stakes were planted at densities of approximately 1,000 stems per hectare (R. Moody, pers. comm.).

Figure 1-5: Cottonwood stakes at McKay Creek, one year after planting (April 27, 2011)

1.7 Habitat Selection

In addition to monitoring the effectiveness of the physical works projects mentioned above, CLBMON 11B-2 studies habitat selection by migrating songbirds. The goal of this component is to determine which drawdown zone habitats are selected by migrating songbirds so that recommendations can be made for future WPW or RPW projects, and to provide information on the effects of reservoir operations on the availability of spring migratory bird habitat. Results and conclusions made from this component are necessary for addressing management hypotheses HA_{3A} and HA_{3B} (Appendix 6-1). This component was initiated in 2009 (Year 1), and an early pilot analysis provided strong evidence that shrubs are used disproportionately by migrating songbirds (CBA 2009b). Future analyses will examine how plant species composition and vegetation density influence habitat use by migrating songbird species.

2 METHODS

A brief overview of the methods used for the effectiveness monitoring and habitat use–availability studies is provided below. For a detailed account of these methods, refer to the CLBMON 11B-2 CBA protocol report (CBA 2011b).

2.1 Study Design

An overview of the study designs and procedures used by CLBMON 11B-2 is provided in Table 2-1. More detailed information is provided below, and in the protocol report (CBA 2011b).

2.1.1 Layout and Design of the Effectiveness Monitoring Components

Effectiveness monitoring of WPW and RPW projects required repeated monitoring of the areas that were modified; therefore, permanent plots were established and monitored repeatedly on a weekly basis during the spring for all revegetation treatments and WPW projects. Established plots were 50 x 50 m for most sites, although the plots for some cottonwood stake revegetation sites were irregularly shaped but of a similar size (approximately 2,500 m^2).

2.1.1.1 WPW6A

Both the 2010 and 2011 field seasons provided data prior to implementation of the WPW projects (i.e., "before"). Results can inform on the value of the status quo habitat for migrating songbirds. If an equivalent sampling effort of ("after") occurs following project implementation, a before-after design could be used to determine if the habitat modifications resulting directly from WPW6A impact the use of the area by migrating songbirds. This component will be used to address management hypotheses HA_{2A} and HA_{2B}. The four permanent plots were established in 2010; these covered most of the footprint area of the WPW project. The footprint area was defined as the erosion channel (Figure 1-3), which is comprised of unvegetated soil or mud, with steep side walls, and several turf-shelves of grassland habitat that have calved off the steep sides of the erosion channel (Figure 1-3, Figure 2-1).

The remaining parts of the plots that were above the footprint area were primarily grassland habitat (reed canarygrass with horsetail), and a section of river channel and sandy river shoreline habitat with driftwood. A minor amount of shrubby habitat was also present in the corners of two plots. Monitoring was also conducted at the Airport Marsh wetlands, which are being protected by WPW6A. Monitoring in the marsh was conducted at random plots on a weekly basis as part of the habitat use–availability study (see Section 2.1.2).

2.1.1.2 WPW14/15A

WPW14 and WPW15A will impound terrestrial habitats in the Cartier Bay wetland area. The footprint area was defined as terrestrial habitat surrounding the Cartier Bay "lake" that will be flooded (generally below 434.75 m). In 2010, a series of fixed plots were monitored for habitat usage prior to impoundment so that the impact of impounding the terrestrial habitats could be quantified. The 2010 study was designed as a single year effort to estimate the cost of the project in terms of loss of terrestrial habitat for migrating songbirds[1].

In 2011, we used a different design to assess how usage of the shoreline habitat changes with reservoir elevation, and if that usage changes following implementation of the project. A single encounter transect was surveyed on a weekly basis. The survey transect followed the inside shoreline of the pond in Cartier Bay (Figure 2-2**Error! Reference source not found.**) in order to document songbird habitat usage along the shoreline. This sampling will be repeated after the completion of the physical works project.

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[1] Benefits to waterbirds resulting from this WPW project will be assessed separately by the CLBMON 40 monitoring program.

Table 2-1: Table summarizing details of the five component studies of CLBMON 11B-2 monitored in 2011

Component Study	Method	Design Type	Statistical Population	Sample Units	Sample Period	Weekly Effort
WPW14/15A	Encounter Transect	Repeated Measures	Site	1 Transect	~ 3 hrs	~ 3 hours
WPW6A	Landbird Migration Survey	Repeated Measures	Site	4 Sub-plots	10 mins	40 minutes
Cottonwood Stakes	Landbird Migration Survey	Repeated Measures	Study Area	27 Independent Plots	10 mins	4.5 hours
Water Sedge	Landbird Migration Survey	Repeated Measures	Site	12 Sub-plots	5 mins	1 hour
Habitat Selection	Landbird Migration Survey	Stratified Random Samples	Study Area	Min. 1 Plot per Strata	30 mins[1]	5 hours

1. Considerably more time was required per plot for measuring plot characteristics

Figure 2-1: Field technician monitoring songbird habitat usage at the WPW6A site, May 2011

Figure 2-2: Example of an encounter transect used to survey the shoreline of Cartier Bay. The transect started and ended at the same general location each week, but the route was modified to stay within 1 m of the shoreline, as influenced by reservoir elevations

2.1.1.3 Water Sedge and Cottonwood Stake Monitoring Sites

A longitudinal design is being used to measure habitat effects of revegetation sites. These sites were monitored repeatedly throughout the field season in 2011. Similar monitoring will be repeated every year until the treatment has matured (i.e., until the plants are full size) up to a maximum of eight more years or terminated if we conclude the treatments have failed. This longitudinal design will be used to address management hypotheses HA_{1A} and HA_{1B}.

In 2010, 12 permanent sub-plots were established within a single large water sedge treatment site in the 9 Mile area (Figure 2-3). Control sites for sedge monitoring were not identified because it was difficult to replicate comparable site conditions for these treatments.

The effectiveness of the cottonwood stake treatment is being monitored with treatment (Cottonwood T) and control (Cottonwood C) plots. Eleven treatment and eight control plots were established in 2010; in 2011 we increased the number of monitoring plots to 16 treated and 11 control plots (Figure 2-3). Control plots were in habitats that were similar to the treated areas and were often located adjacent to treated plots. Two control plots were left unplanted for monitoring purposes, the remaining nine control plots were unplanted sites chosen for their similarity to the sites that were treated. Habitat heterogeneity among sites was relatively minor, so habitat blocking was not considered to be necessary. Plots were irregularly shaped due to the patchy nature of this treatment but were similar in size (2500 m^2) to the standardized square plots. Plots were sampled weekly, and like the other RPW effectiveness monitoring components, will be re-sampled on a weekly basis over multiple years. The null hypothesis of interest is that (after controlling for seasonal effects) the treatment*time interaction does not predict rates of songbird habitat usage (time being measured over many years). A significant interaction term would indicate that usage has changed predictably over time, but differently for treatment and controls, therefore providing grounds to reject management hypotheses HA_{1A} and HA_{1B}.

Figure 2-3: Permanent plots for monitoring the effectiveness of cottonwood stake and control, water sedge, WPW6A, and WPW14/15A treatments

2.1.2 Design of the Habitat Selection Component

A stratified random sampling design is being used to determine habitat selection by migrating birds. Plots were sampled one time only, with new random plots selected annually since 2009. The entire study area was subdivided into a grid of 50 x 50 m cells, creating 27,855 potential sample plots. Each 50 x 50 m cell was classified as one of six habitat strata: wetland, forest, shrub, grass-dominated, non-vegetated, or open water (CBA 2010c). The open water stratum was excluded from the study. A stratified random sampling program was used to select sample plots from each of the strata within the upper accessible portion of the study area (access is limited south of 12 Mile; Figure 2-4). We attempted to sample all strata on a weekly basis, when possible. In 2011, reservoir elevations restricted the availability of randomly selected unvegetated plots. Plot characteristics were measured after every sampling occasion.

2.2 Field Sampling Procedures

All monitoring in 2011 was conducted over seven weeks during the spring migration (late April to early June).

2.2.1 Procedures for Monitoring Migrant Birds on the Cartier Bay Transects

Encounter transect sampling was conducted weekly at Cartier Bay by a single observer. The observer started near the junction of roads at UTM zone 11/418862/5642927, and walked slowly around the inside curve of Cartier Lake, never moving farther than 1 m from the shoreline, and never crossing water deeper than 30 cm. The transect ended when the observer reached the rail grade (Figure 2-2).

Along the transect, the observer encountered groups of migrant songbirds on the ground ahead and upslope of the shoreline. A waypoint was recorded when birds were observed, and a distance and direction were assigned to the observation. Birds were recorded as being within 1 m of the shoreline, between 1 and 5 m of the shoreline, between 5 and 10 m of the shoreline, or greater than 10 m from the shoreline. Waypoints were then calculated using the distance and direction to get an accurate location for bird observations.

2.2.2 Procedures for Monitoring Migrating Birds at Plots during the Spring Migration

We used a modified point count procedure for detecting bird activity at random and fixed plots. Because songbirds are not territorial during spring migration and do not sing consistently, a single location point count was not used. Instead, observers moved about within the study plots during the sampling period as necessary to maximize visual detection of birds. The sampling period began as the biologists entered the plot so that birds flushed from the plot were included. Birds were identified to species, and the number of detections (i.e., a single detection could be of a single individual or a flock of two or more birds) and number of individuals were recorded.

The sampling period was 10 minutes for permanent plots sampled on a weekly basis for all effectiveness monitoring studies with spatial replication; the water sedge study did not have spatial replication because all 12 plots were at one site; hence, we reduced the sampling at each of the 12 subplots to 5 minutes in 2011, which amounted to 1 hour of observation at this site each week. A longer period for sampling at permanent plots was not possible given the volume of sampling that was needed on a weekly basis. A 30-minute sampling period was used for randomly selected plots (habitat use-availability) in order to maximize the quality of data collected for these one-time-only samples.

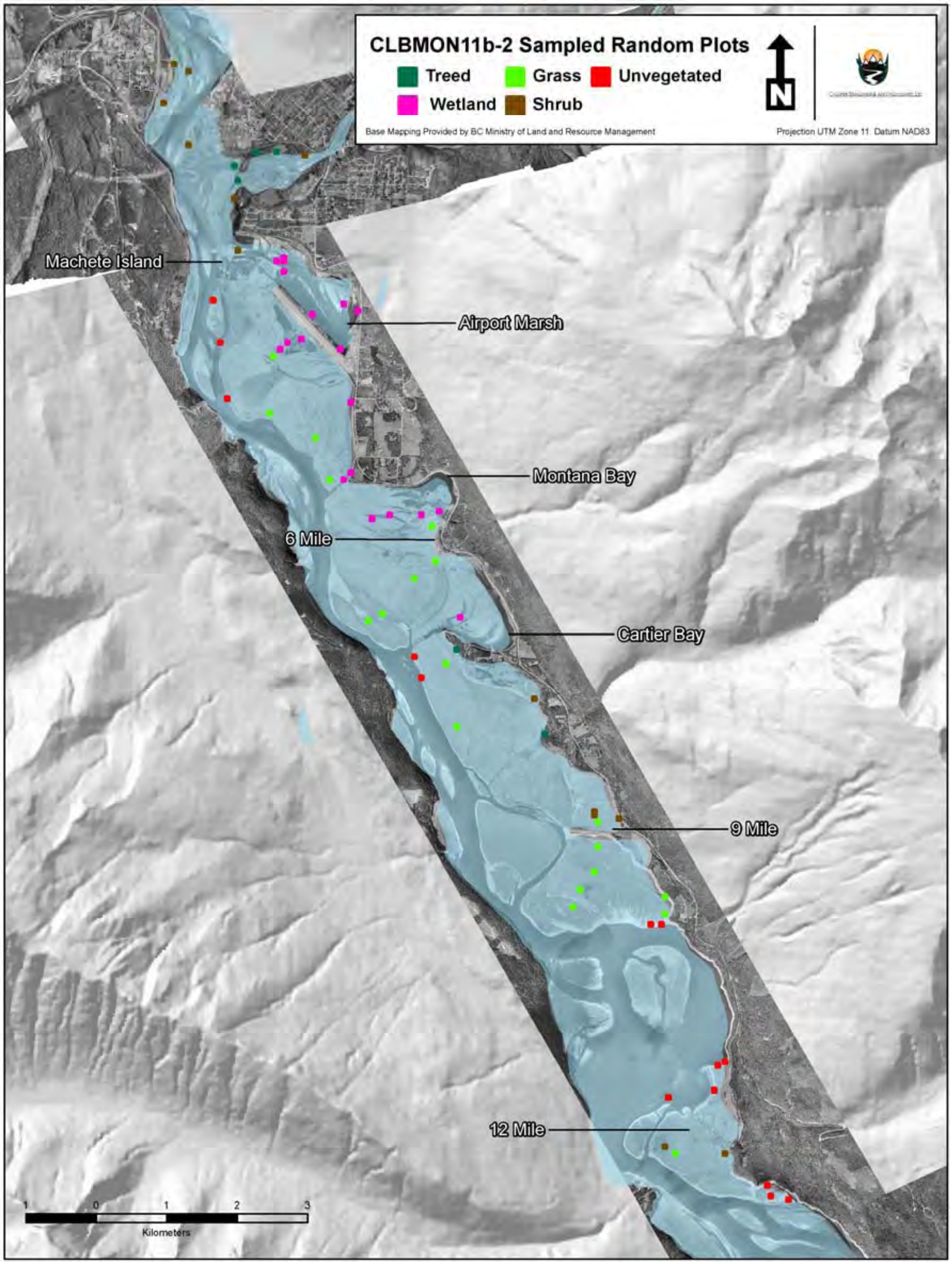

Figure 2-4: Locations of randomly selected plots surveyed in 2011

For all studies, the sampling periods were divided into six 5-minute sampling intervals, and the interval in which each bird was detected was recorded. During the sampling period, birds observed flying directly above the plot were classified as “overhead”, and those detected using habitats on the plot were classified as “on-plot”. All other detections were classified as “off-plot”. For effectiveness monitoring of WPW6A, on-plot detections were determined to be either in or outside of the footprint area.

2.2.3 Procedures for Characterizing Habitats

Habitat characteristics were recorded for the habitat use-availability study. Habitat plots were characterized according to their structural complexity (CBA 2010c). The recorded characteristics were intended to be used as independent predictors of bird detections. “Open Habitat” was defined as habitat that was not covered by a shrub or tree, and areas of open habitat were classified as one of 15 habitat types (CBA 2010c). Ground vegetation in non-open habitats was not recorded. We did not record ground cover under shrubs; given the large size of the plots, collecting such details would be time consuming, difficult to quantify, and unlikely to be strong predictors of most songbird detections. Shrubs were defined as woody perennials not taller than 1.5 m, and all components of this vegetation layer were classified to genus or species. Tall shrubs were defined as woody perennials between 1.5 and 5 m tall, and all components of this vegetation layer were classified to genus or species. Trees were 5 m or taller, and the coverage of each species was calculated.

2.3 Data Reporting and Analysis

The purpose of this report is to review progress made in 2011 (Year 3). Detailed analyses that address the management questions and hypotheses will be conducted in Year 5 and Year 10 of this study. Detections of migrating songbirds are reported. Non-migratory songbirds and non-passerines were recorded at random plots but were not included in the results section of this report.

2.3.1 Effectiveness Monitoring of Revegetation and Wildlife Physical Works

Effort allocated to effectiveness monitoring was recorded. Detection rates and diversity of birds (within plots and within weeks) were computed for each effectiveness monitoring plot.

2.3.2 Habitat Selection

Effort allocated to assessing habitat selection, and the number of bird detections by species and by habitat strata were tabulated for this report. All three years of data were summarized for random plots. Exploratory binary analyses were performed on these data (see Section 2.3.5).

2.3.3 Vegetation Plot Characteristics

Vegetation plot characteristics were summarized by tabulating the vegetation coverage and species found in each habitat strata. Analysis of how vegetation characteristics predict songbird detections will be preformed in Year 5 and Year 10 of the study.

2.3.4 Timing of Migration

To accurately quantify the timing of migration of songbird species through the study area, including uncommonly detected species, bird detections from “on-plot”, “overhead”, and “off-plot” were pooled from all random sampling done in 2009 through 2011.

2.3.5 Statistical Methods

Full analyses to address the management questions for this report were not conducted because they would be inappropriate given the early stages of this research. For the purposes of summarizing our results in Year 3, exploratory tests were performed occasionally to provide perspective on the nature of early results. The program “R” was used for most data manipulation, graphing, and for all statistical computations (R Development Core Team 2006).

The R package “ggplot2” was used for graphing (Wickham 2009). To deal with over plotting (when data hide other data on graphs), we often set data points to be transparent by modifying their ‘alpha’ setting (Wickham 2009). When this technique was used, we noted the alpha level in the figure caption to allow the reader to assess how many points are overlapping. When alpha = 1, there is no transparency; when alpha = 1/10, 10 overlapping points are required to remove their transparency. In some cases, we also used the “jitter” function to prevent over plotting; this function wiggles the data slightly so that the similar plotted points to not lie on top of each other (Wickham 2009). When used, we set the function to jitter the points slightly to the left and right (but not up and down).

Statistical procedures included chi-square tests of independence for contingency tables (Zar 1999). We also used binomial generalized linear models with a logit link function (Zuur et al. 2009) in preliminary analyses to test if the presence/absence of a migratory songbird at a random plot was dependent on willow versus cottonwoods. The same type of model was used to analyze the effects of vegetation layers (tree, tall shrubs, shrubs, and open habitat) on the probability of detecting at least one migrating songbird. When multiple predictors were included in a model, we removed non-significant terms one at a time, in order of least significance, and refit the model after each step. Akaike’s Information Criterion (AIC) is reported to assess the relative performance of candidate models with respect to their balance between goodness of fit and complexity (Zuur et al. 2009). In all statistical tests, effects were considered significant if the two-tailed probability was less than 0.05.

3 RESULTS

The winter of 2010/11 was characterized by a deep valley-bottom snowpack. The timing of the spring snowmelt was relatively normal, with much of the northern part of the study area still covered by snow in early April. By late April when field sampling started, most of the snow had melted, but there were considerable amounts of snow water, which kept ponds filled to maximal levels throughout spring (Figure 3-1). Weather was typical during the early spring, albeit slightly cool, with frequent precipitation and occasional sunny weather.

Reservoir elevations were lower than those in 2010 (Figure 3-2). The main pond at Cartier Bay did not become flooded by the reservoir until the first week of June.

Figure 3-1: **The study area on April 22, 2011, just prior to field sampling: (top) Machete Ponds; (bottom) Locks Creek Outflow**

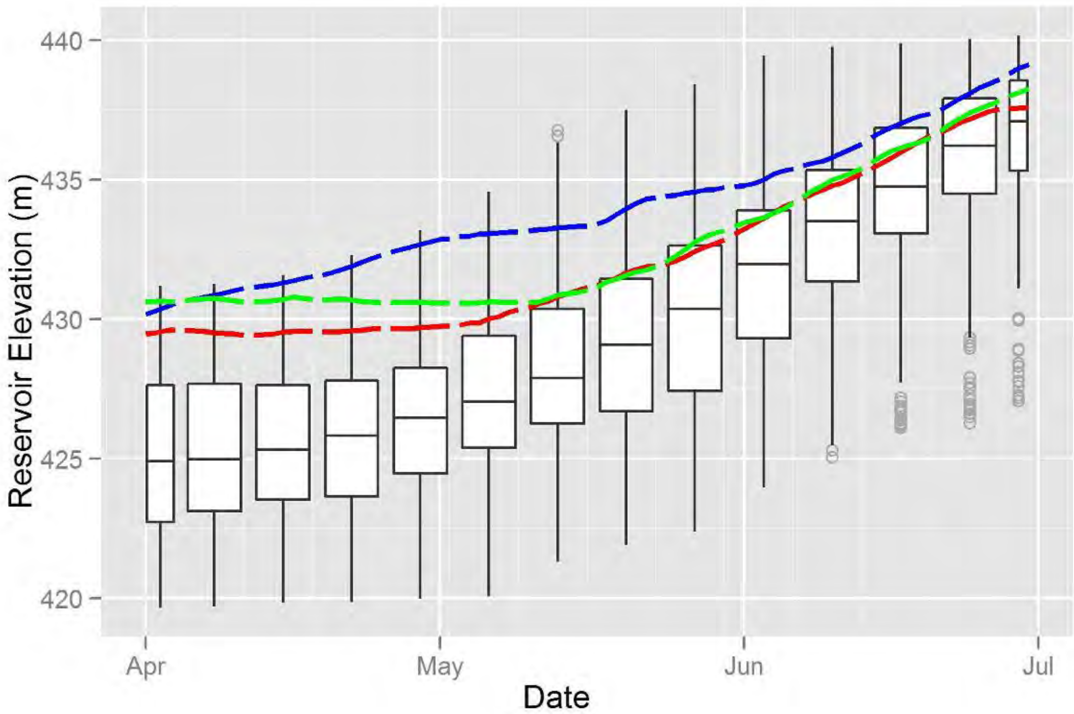

Figure 3-2: **Reservoir elevations during the first three spring field seasons, plotted in red (2009), blue (2010), and green (2011) in relation to box plots of weekly reservoir elevations recorded since 1969**

3.1 Effectiveness Monitoring of Revegetation and Wildlife Physical Works

3.1.1 Effectiveness Monitoring for WPW6A

Four permanent plots were surveyed weekly for seven consecutive weeks (28 samples) starting on April 27, 2011. The last survey was conducted on June 8, 2011. Random sampling was conducted at the Airport Marsh throughout the season (nine plots).

At the four permanent plots at the proposed construction site, 186 migrating songbirds (seven species) were observed on-plot or overhead; 55 of these (five species) were recorded on-plot during the seven survey weeks (Figure 3-3; Appendix 6-2). Three migrant songbird species were recorded using the footprint area: 41 American Pipits (two detections), one Marsh Wren, and one Savannah Sparrow. No non-target bird species were recorded using the footprint area.

Of the 106 migrating songbirds detected flying over the plots, most were American Pipits, followed by Yellow-rumped Warblers; aerial insectivores accounted for just 2% of these detections.

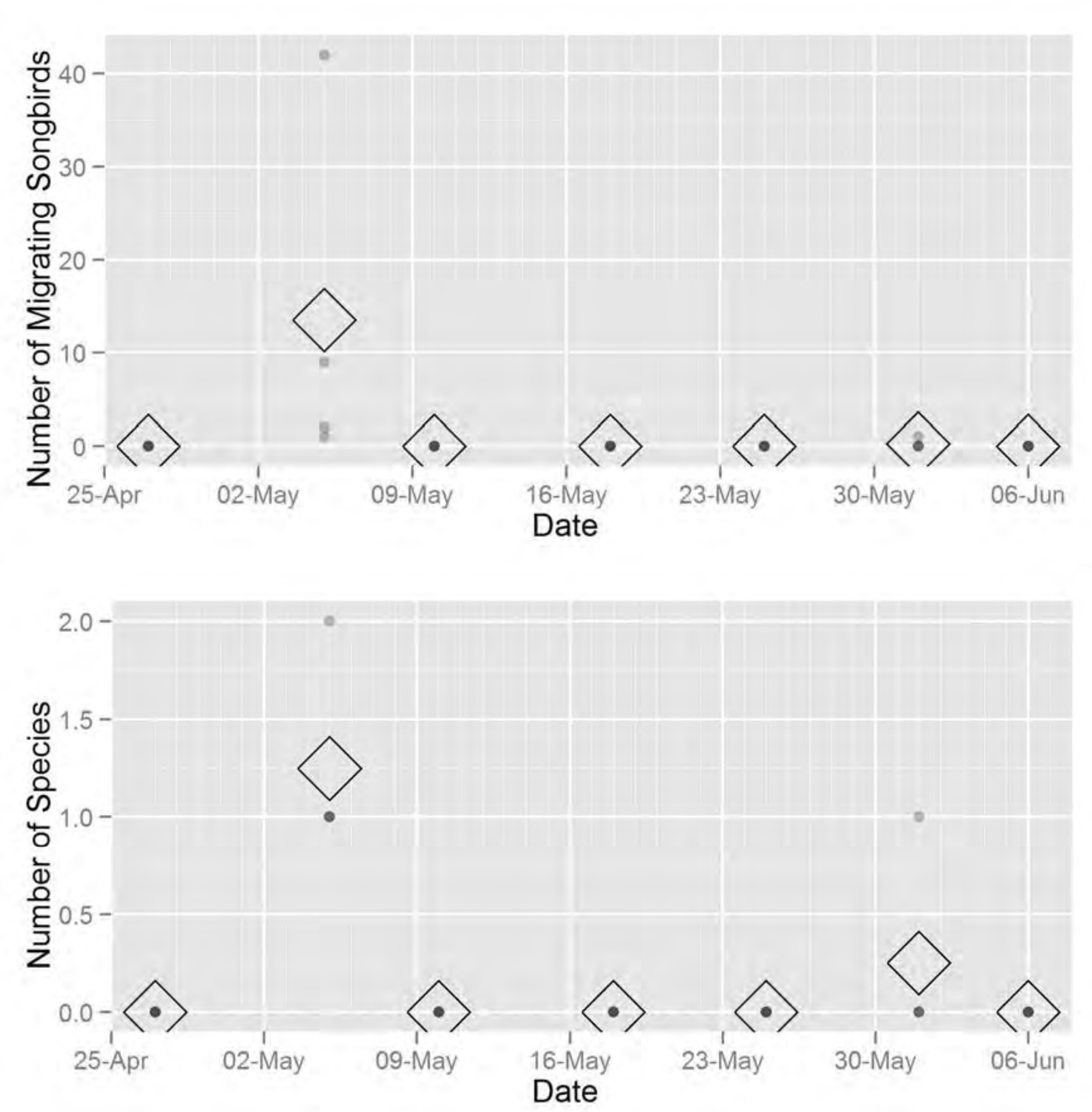

Figure 3-3: **Total number (top) and diversity (bottom) of migrating songbirds detected on-plot at the four permanent plots at the WPW6A work area over time. Raw data points are plotted as points (alpha = 1/4); weekly averages are plotted as diamonds**

3.1.2 Encounter Transects at WPW14 and WPW15A

Seven weekly encounter transects were surveyed; 997 migrating songbirds (two species) were observed on the ground during the surveys (Appendix 6-3, Figure 3-4). American Pipits accounted for 99% of the detected birds, and 649 of them were detected within 10 m of the shoreline (Appendix 6-3, Figure 3-4). A relatively large proportion (32.5%) of the pipits observed within 10 m were using a narrow 1-m strip of habitat next to the water (Figure 3-4). Most (97%) of the migrating songbirds were observed in the first three surveys (Figure 3-5), long before the reservoir had considerable influence on the habitat.

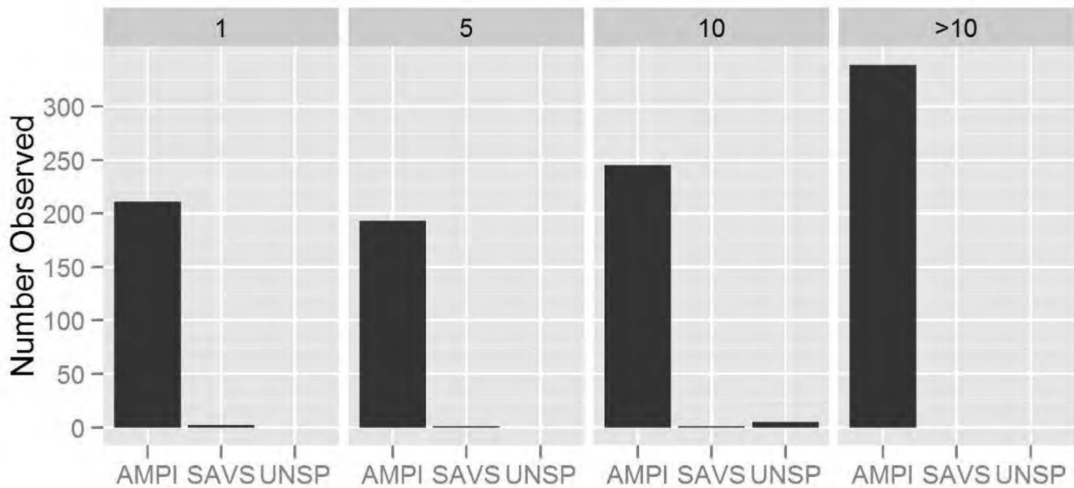

Figure 3-4: Number of observed migrating songbirds, by species and distance zone (1 ≤ 1 m from shore, 5 ≤ 5 m from shore, etc.). AMPI = American Pipit, SAVS = Savannah Sparrow, UNSP = unidentified sparrow

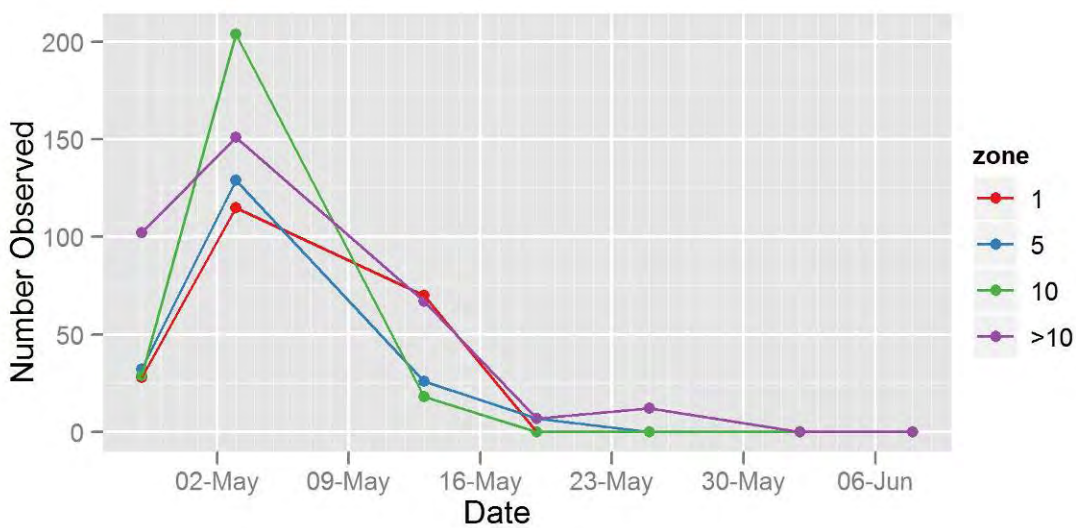

Figure 3-5: Number of observed migrating songbirds by date and zone (meters from waters edge)

3.1.3 Effectiveness Monitoring of Water Sedge Plugs

The 12 subplots of the one large water sedge treatment were surveyed weekly for seven consecutive weeks (84 subsamples) starting on April 27, 2011. The last survey was conducted on June 7, 2011.

In total, 269 migrating songbirds (11 species) were detected overhead and on-plot at the 12 permanent plots over the course of seven survey occasions (Figure 3-6, Appendix 6-4); 162 birds from four species were recorded on-plot. American Pipit was the most abundant species recorded on-plot and overhead.

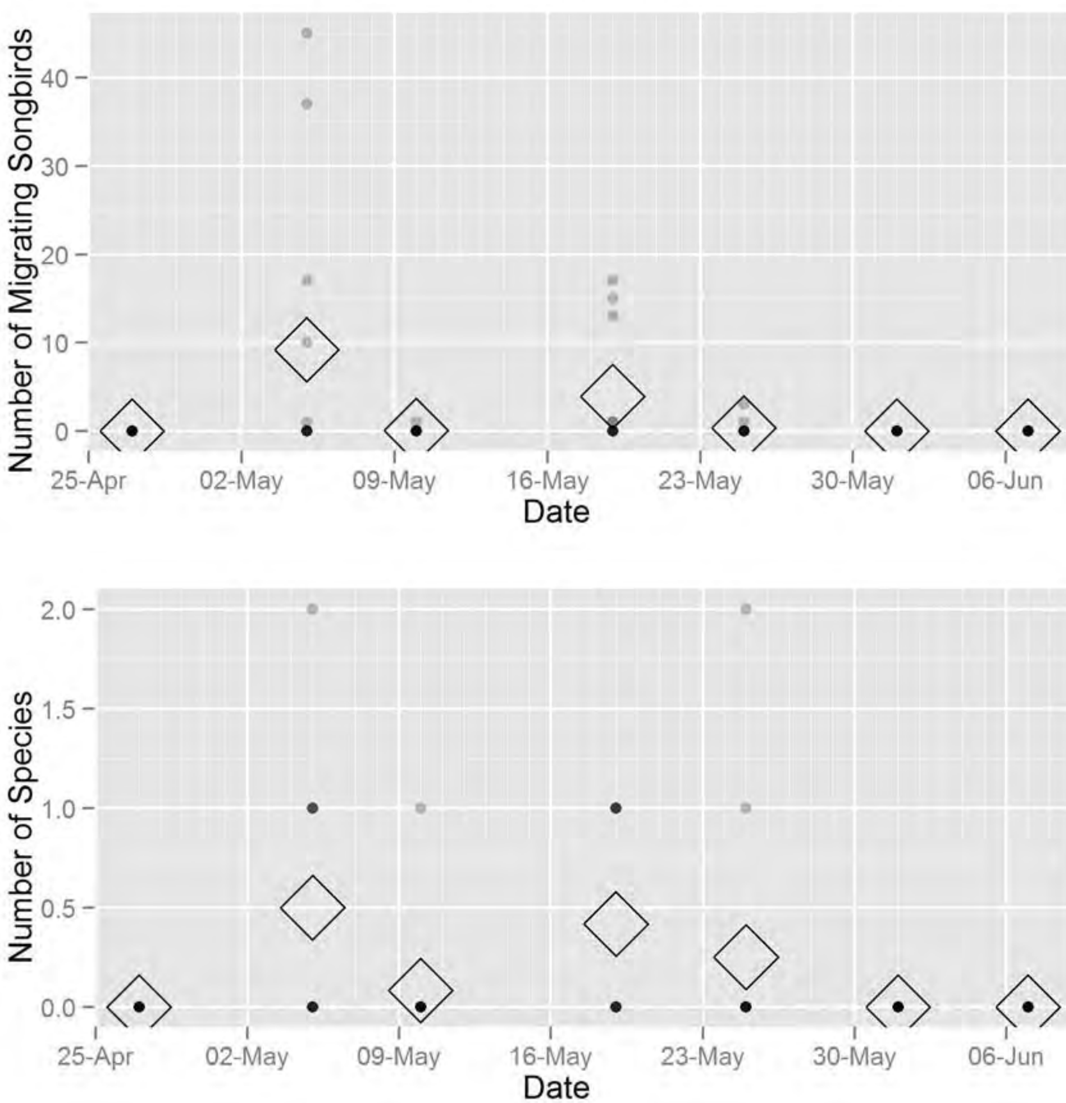

Figure 3-6: Total number (top) and diversity (bottom) of migrating songbirds detected on-plot at the 12 permanent subplots at a large site revegetated with water sedges over time. Raw data points are plotted as points (alpha = 1/4); weekly averages are plotted as diamonds

3.1.4 Effectiveness Monitoring of Cottonwood Stakes

The 27 permanent plots were surveyed weekly for seven consecutive weeks (188 samples; one new plot was not sampled in the first week) starting on April 27, 2011. The last survey was conducted on June 8, 2011.

In total, 447 migrant songbirds (142 birds and 15 species at 11 control plots; 305 birds and 26 species at 16 treated plots) were detected on-plot or overhead of the 27 permanent plots (Appendix 6-5, Appendix 6-6). A total of 16 migrating songbirds (five species) was recorded on-plot at controls, while 86 birds (11 species) were detected on-plot at the treated plots. In every week of surveys, both the average number of birds, and the average number of species recorded on-plot was greater at treated plots than in control plots, although these effects were small (Figure 3-7). The result of consistently having a larger mean on all seven occasions is statistically significant (χ^2 = 10.28, Fisher's exact p = 0.0006).

Yellow-rumped Warbler was the most abundant species (Appendix 6-5, Appendix 6-6), with a total number of 138 birds detected on-plot or overhead, including those classified as Audubon's Warbler (Myrtle Warblers were not identified at these sites); 94 of these birds were detected at treated sites (5.8 detections per treated plot, 4 detections per control plot). Seven birds were detected on-plot at control plots (0.63 birds per plot), while 22 were detected on-plot at treated plots (1.4 birds per plot).

American Pipits were the second most abundant species detected but were never detected on-plot (Appendix 6-5, Appendix 6-6). American Robins were the third most numerous: 0.36 birds per plot were detected in controls, while 0.44 birds per plot were detected at treated plots.

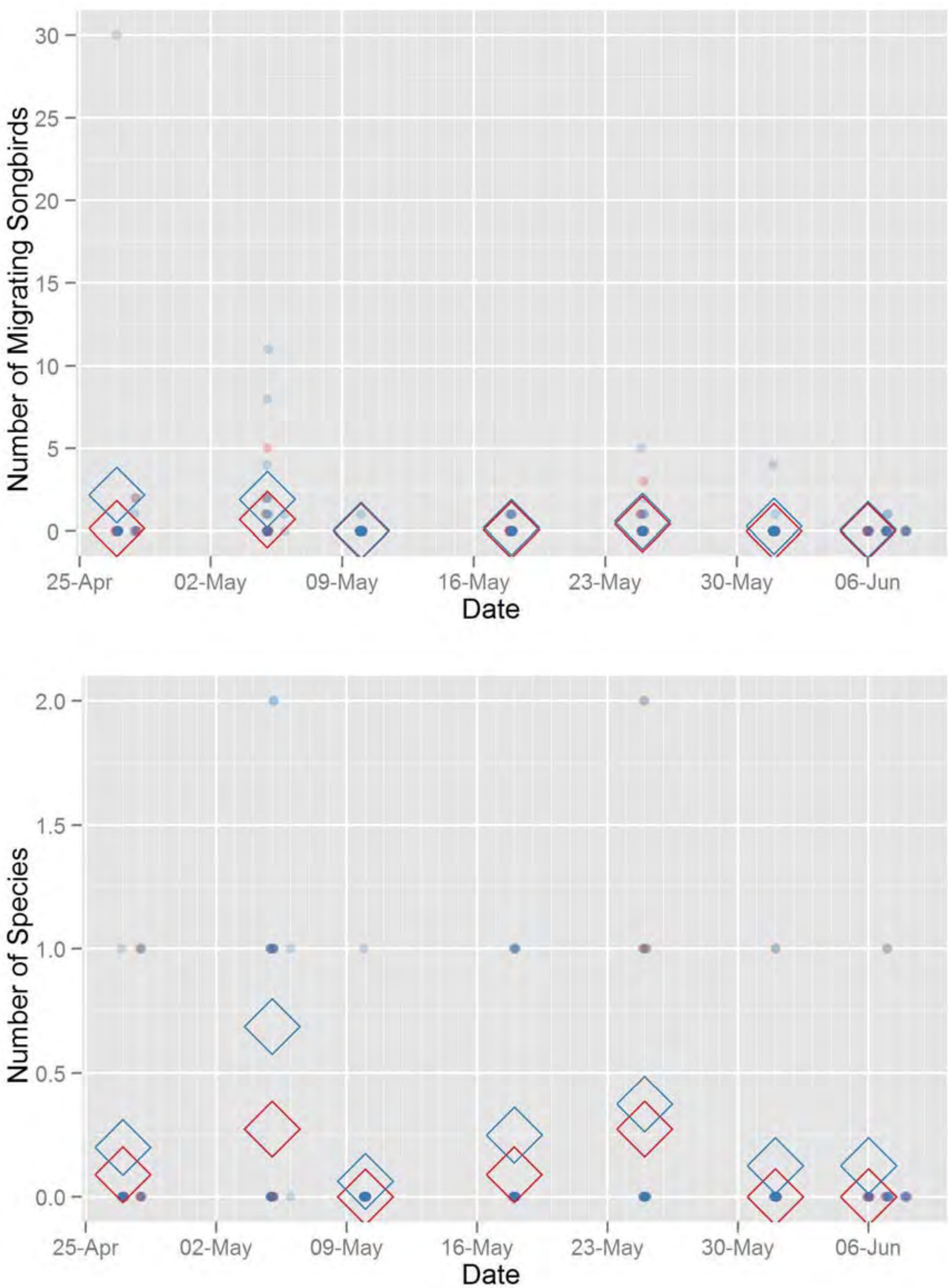

Figure 3-7: **Total number (top) and diversity (bottom) of migrating songbirds detected on-plot at the 11 control plots (red) and 16 plots revegetated with cottonwood stakes (blue) over time. Raw data points are plotted as points (alpha = 1/4) and "jittered" to diminish over plotting; weekly averages are plotted as diamonds**

3.2 Random Sampling

In 2011, 71 randomly selected plots were surveyed over seven weeks for a combined 35.5 hours of bird observation. The first random plot was sampled on April 28, 2011; the last one was sampled on June 3, 2011. In total, 915 individuals of 43 species of migrating songbirds were detected (Appendix 6-7), and twenty species were recorded on the plots. American Pipit was the most abundant species recorded on-plot and overhead, but Yellow-rumped Warblers were more abundant off-plot.

Over three years (2009–2011), there were indications that the number of species detected on-plot was limited by the number of plots that were surveyed each year (Figure 3-8). Conversely, the total number of species observed (all species, all locations), and the total number of migrating songbird species observed from all locations within each year was relatively consistent (Figure 3-9).

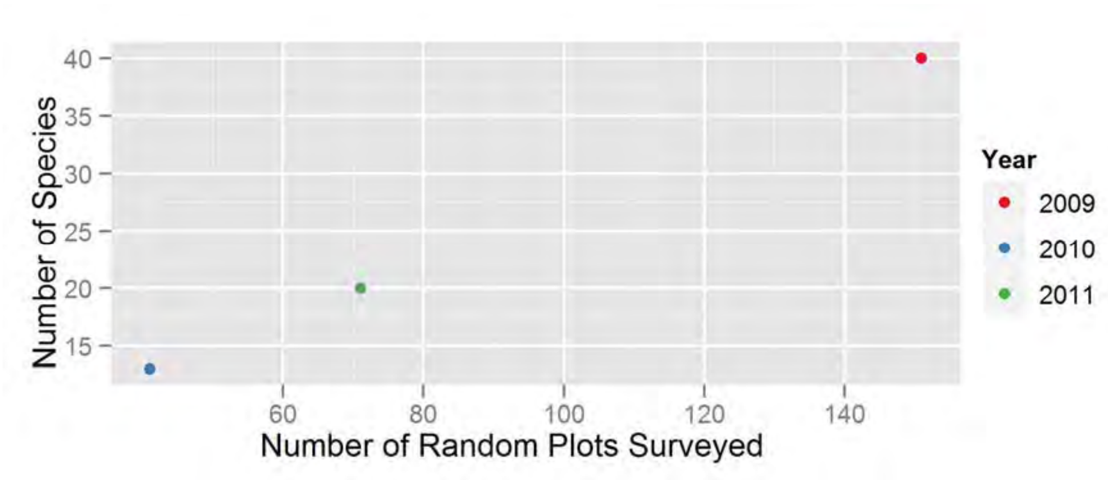

Figure 3-8: **Total number of species detected on-plot at random plots within each spring season plotted against the number of random plots surveyed**

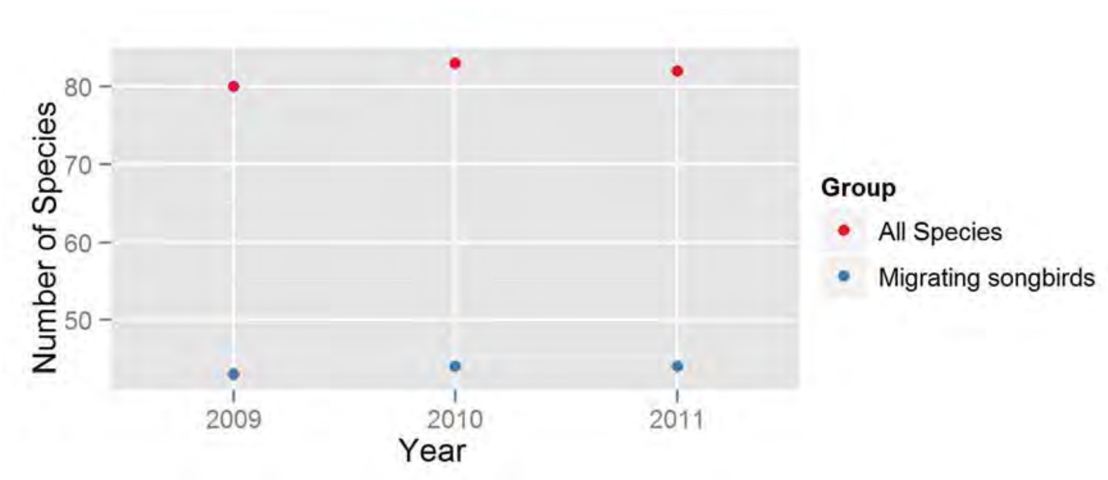

Figure 3-9: **Total number of bird species and the subset that were migrating songbirds plotted for each of three years of sampling**

3.2.1 Vegetation Sampling at Random Plots

During three years of field work, sampling was conducted at 23 Forest plots, 54 Grassland plots, 88 Shrub plots, 18 Unvegetated plots, and 79 Wetland plots.[2] Plot characteristics were collected at all these random plots, and the data showed expected differences among strata (Table 3-1).

Table 3-1: Vegetation layers by habitat strata from the random plots sampled over three years

Strata	Layer	Minimum (% cover)	Average (% cover)	Maximum (% cover)
Unvegetated	Open Habitat	0	77	100
	Shrubs	0	1	10
	Tall Shrubs	0	0	1
	Tree	0	0	0
Grassland	Open Habitat	0	84	100
	Shrubs	0	1	5
	Tall Shrubs	0	2	95
	Tree	0	0	5
Shrub	Open Habitat	0	61	100
	Shrubs	0	14	85
	Tall Shrubs	0	13	65
	Tree	0	8	75
Wetland	Open Habitat	0	87	100
	Shrubs	0	4	40
	Tall Shrubs	0	3	40
	Tree	0	1	30
Forest	Open Habitat	0	32	91
	Shrubs	0	15	60
	Tall Shrubs	0	14	60
	Tree	0	43	95

3.2.2 Habitat Selection

The probability of detecting a migrating songbird differed among habitat strata when all three years of data were combined (n = 260, χ^2 = 32.26, df = 4, p = 0.0000002, Figure 3-10: top). In most strata, there was considerable consistency among years with respect to the percentage of plots where at least one migrating songbird was detected, but results from the Forest strata were highly variable (Figure 3-10: bottom).

Three binary models were built to examine the predictive importance of cottonwood cover, willow cover, and amount of open habitat on the detection of one or more on-plot migrating songbirds (Table 3-2). Although the AIC did not differ greatly between the three candidate models (Table 3-2), the only significant explanatory variable in all models was the amount of open habitat; therefore, we chose M3 as the best model. In M3, the

[2] Additionally, one Open Water plot was sampled, but is omitted from the presented results

intercept was estimated at 1.26, and the slope (β) as -0.19 with p = 0.000002 (Figure 3-11).

Preliminary plot characteristic modelling to examine the relative importance of vegetation layers (tree cover, tall shrub cover, shrub cover, and amount of open habitat) as predictors of the detection of one or more on-plot migrating songbirds (Table 3-3), showed highly significant effects of each variable in univariate models (M4, tree, p = 0.005; M5, tall shrub, p = 0.00002; M6, shrub, p = 0.00007). In the full multivariate model (M7, Table 3-3), only one term was not significant (tree cover), so we removed this term and refit the model (M8, Table 3-3). All terms in M8 were weakly significant (0.01 > p < 0.04), and this model had the lowest AIC. In all models, the slopes (β) estimated for tree cover, tall shrub cover, and shrub cover were positive. In M7 and M8, the slopes (β) estimated for open habitat were negative. The greatest slope (β) estimated was for tall shrub cover (M5, β = 0.07, Figure 3-12).

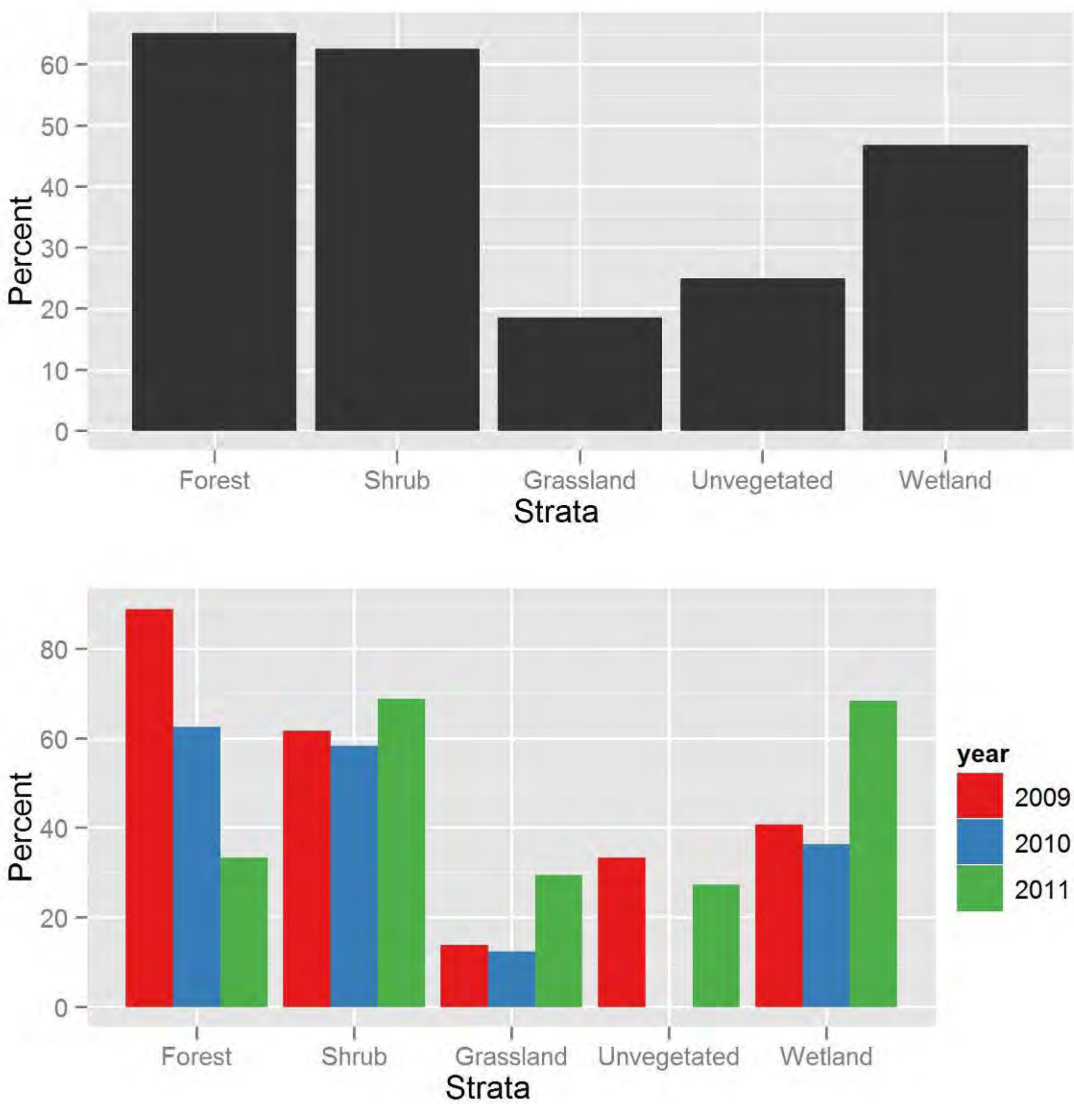

Figure 3-10: Percentage of random plots sampled in each strata where at least one migrating songbird was detected on-plot. Three years of data are combined (top) and graphed separately (bottom)

Table 3-2: Binary models used to examine the relative importance of cottonwood cover (cot), willow cover (wil), and amount of open habitat (oh) as predictors of detecting at least one migrating songbird (MS) at a random plot (Int = intercept, ε = error)

Name	Model	AIC
M1	MS = Int + β(wil) + β(cot) + β(oh) + ε	340.3
M2	MS = Int + β(wil) + β(oh) + ε	338.7
M3	MS = Int + β(oh) + ε	338.3

Table 3-3: Binary models used to examine the relative importance of vegetation layers—tree = tree cover, tall shrub = tall shrub cover, shrub = shrub cover—and amount of open habitat (oh) as predictors of detecting at least one migrating songbird (MS) at a random plot (Int = intercept, ε = error)

Name	Model	AIC
M4	MS = Int + β(tree) + ε	354.3
M5	MS = Int + β(tall shrub) + ε	334.8
M6	MS = Int + β(shrub) + ε	341.7
M7	MS = Int + β(tree) + β(tall shrub) + β(shrub) + β(oh) + ε	326.9
M8	MS = Int + β(tall shrub) + β(shrub) + β(oh) + ε	324.9

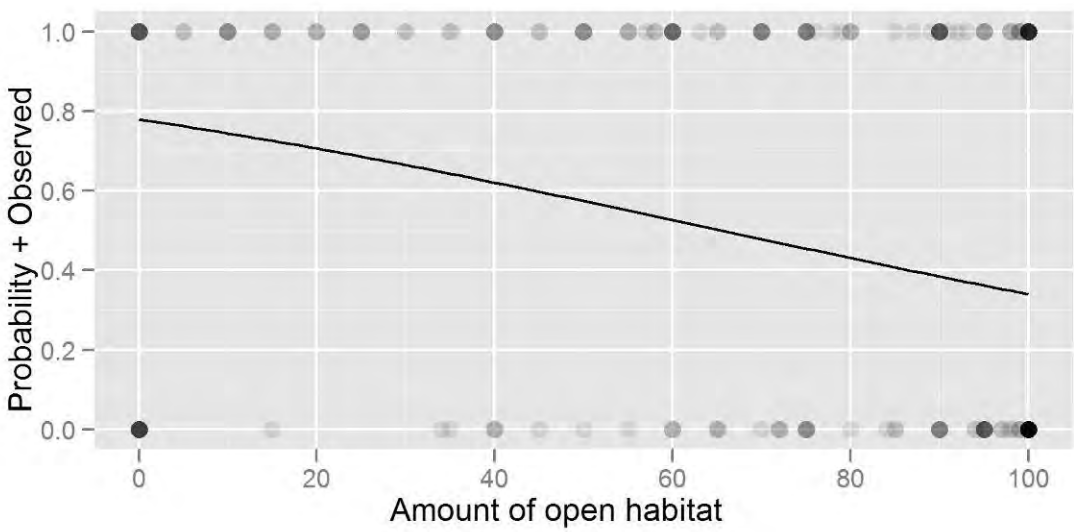

Figure 3-11: The function predicted by M3 and the observed data (1 = plots with detections; 0 = plots without detections; alpha = 1/10)

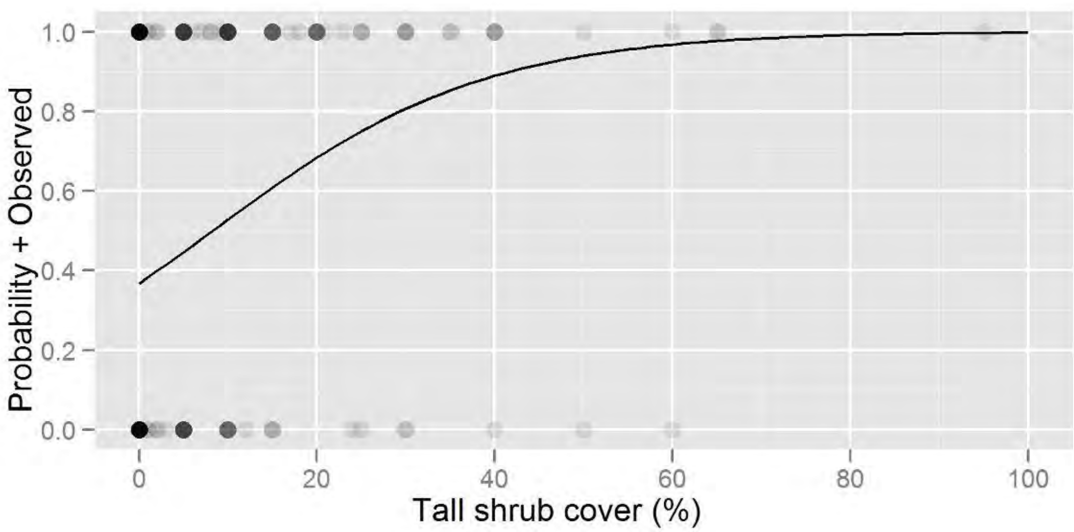

Figure 3-12: The function predicted by M5 and the observed data (1 = plots with detections; 0 = plots without detections; alpha = 1/10)

3.2.3 Timing of Migration at Random Plots

Peak migration periods varied considerably by species (Figure 3-13). Furthermore, these tendencies were often consistent among years. For example, American Pipits and Savannah Sparrows were most abundant in the first two weeks of May in all three years, Orange-crowned Warblers were most abundant in mid May in all three years, and American Redstarts consistently arrived in late May. There was a tendency for migrants to show up earlier in 2010 than in 2009 and 2011 (Figure 3-13). Many of the tyrant flycatcher and Parulidae warbler species were late migrants (Figure 3-13).

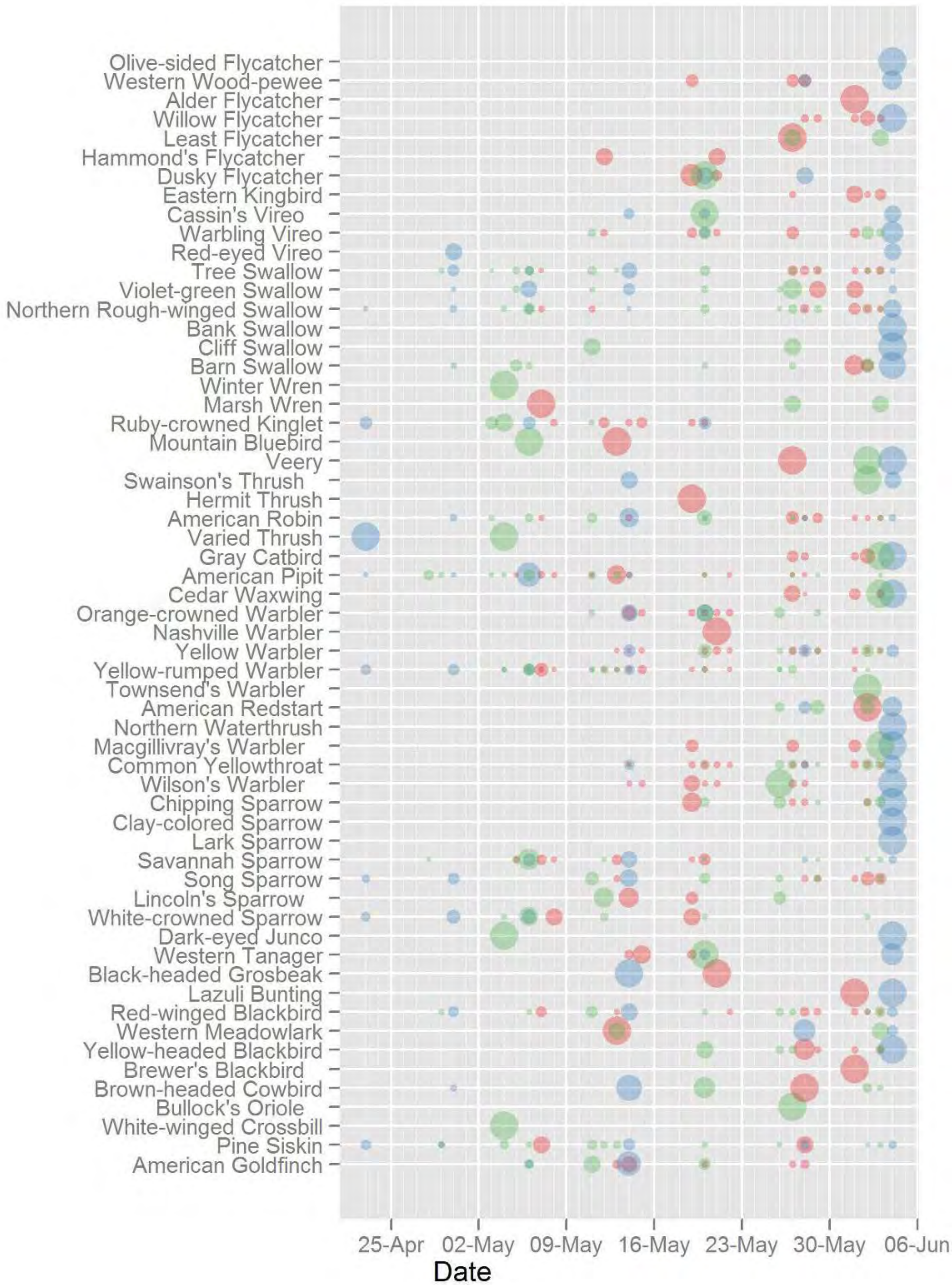

Figure 3-13: **Three years of random plot data (red = 2009, blue = 2010, green = 2011) showing variation in the timing of records for all migrating songbird species. The size of the dot is scaled to the percentage of birds observed annually on each day**

4 DISCUSSION

Year 3 (2011) was the second year of effectiveness monitoring for three WPW projects and two RPW treatments. The Year 3 results show that the cottonwood stakes are having a positive influence on the number and diversity of migrating songbirds that use the sites. In 2011, we added an encounter transect method for measuring the impacts of WPW15A; and, based on the co-variation of abundance data, the transect method appeared to produce precise and meaningful data on shoreline usage. These results suggest that American Pipits were selecting the near-shore habitats. Continued monitoring using encounter transects along the shoreline of Cartier Bay could demonstrate whether WPW15 impacts this habitat usage via its modification to the shoreline elevation. In Year 3, we dropped the mixed sedge monitoring study from the field studies because of very poor plant survival within this treatment. The mixed sedges were planted in bare ground, and the coverage produced was minimal. Instead, additional treatment and control sites were added to the cottonwood stake monitoring study. In Year 3, we completed a third year of random sampling for the purposes of building habitat selection models for the spring migration. The results are discussed in greater detail section 4.2 below.

4.1 Effectiveness Monitoring of Physical Works

4.1.1 Footprint and Protected Habitats of WPW6A

During winter 2010/2011, the low elevation snowpack was above average. In the spring of 2011, considerable flooding occurred in the fields below Arrow Heights, which drain via the erosion channel; seemingly, this is when much of the erosion occurs at this site.

The footprint area of WPW6A continued to be poorly used by migrating songbirds in 2011, and the data suggest that the erosion channel is not an important habitat for songbirds migrating through the area in spring. We detected a larger diversity of species in 2011 compared with 2010, and we observed larger groups of birds, but the detection rates were similar, and consistent with previous years in showing a relatively low usage of the erosion channel. As such, there should be little concern about negative impacts to migrating songbirds with respect to the modifications proposed by WPW6A.

Our data suggest that proceeding with WPW6A can produce considerable benefits given the importance of wetland habitats for migrating songbirds in spring. Random sampling of wetland habitats over three years showed a relatively large number and diversity of birds using wetland habitat. The goal of WPW6A is to protect Airport Marsh/Machete Pond wetland habitats from being drained via an encroaching erosion channel. These wetlands are some of the most diverse and extensive in Arrow Lakes Reservoir, Lake Revelstoke Reservoir, and Kinbasket Reservoir (CBA 2009c, 2009d, 2010d, 2010e, 2011c, 2011d), so many wildlife groups— both aquatic and terrestrial—will benefit from WPW6A.

4.1.2 Footprint Habitats of WPW14 and WPW15A

WPW14 and WPW15A are designed to enhance habitat for waterfowl and other aquatic wildlife (e.g., amphibians), but the impoundment of terrestrial habitats will potentially affect terrestrial wildlife by reducing habitat availability. Results from the effectiveness monitoring component in Year 2 suggested that the cost in terms of habitat loss for migrating songbirds will not be large or regionally significant (CBA 2010a). The fixed plot design used in 2010 was intended as a single year assessment of footprint impacts to migrating birds. One benefit of this design was that the results could be compared with other components from CLBMON 11B-2, as a way of assessing the value of the habitat that will be removed by WPW14/15A (CBA 2010a). This was possible because the sampling methods were similar. However, in Year 2, sampling was hampered by an unusually early filling of the reservoir, which flooded the plots, complicating the interpretation of the results. The Year 2 design was not well-suited to comparing shoreline usage before and after the treatment. To try and address hypothesis HA_2 (Appendix 6-1), we attempted a new sampling method in Year 3, 2011.

In 2011, we employed an encounter transect method. This method had several advantages; the methodology provided the flexibility to adjust to the changing shoreline, and it was also highly efficient sampling, taking only about three hours to survey each week. The transect method allows shoreline usage to be compared in a before-after analysis if repeated following the habitat enhancement.

Results from the 2011 encounter transects clearly show that the shoreline, in its status quo condition is used by large number of American Pipits during the first two weeks of May; we uncommonly detected Savannah Sparrows, but no other species. American Pipits are not listed as endangered, but large populations utilize the drawdown zone habitats each spring, and Revelstoke Reach drawdown zone likely has regional significance for this species during their spring migration. In Year 2 and 3 in particular, we've noted that Pipit usage is wide-spread throughout the drawdown zone – the species is in no way confined to Cartier Bay, although this site does appear to be particularly favoured by them. American Pipits appear to use low elevation grassland habitats, and we have often noted large groups foraging in the unvegetated depressions, or along the margins of swales and wetlands, similar to the shoreline habitat of Cartier Bay. They also utilize sites covered in low sedge/grass cover. These habitats are widespread throughout Revelstoke Reach in early spring while reservoir elevations are low. The tendency of Pipits to select unvegetated margins of wetlands was captured by our transect data. If we make the assumption that all birds within 10 m of the shoreline were detected, we found that 32% of the detected birds were flushed from within 1 m of the shoreline, suggesting that the near-shore habitat was being disproportionately selected.

Future repetition of these transect surveys can be used to assess the impacts of WPW14 and 15A on shoreline habitat utilization (addressing hypothesis HA_2, Appendix 6-1). Response variables can be the density (number of birds per ha) and the distribution of American Pipits in relation to the water's edge. These variables can be compared before and after the project implementation to see if the new shoreline configuration created by the WPW projects is used in a similar way as the old shoreline.

Methods for surveying songbirds in migration typically involve mist-netting or telemetry tracking, neither of which can work for the types of questions, and scale of this project. This was the first time that we've used the transect method. From our field experiences and based on the results had in 2011, we suggest that transects may be a particularly productive and accurate way to survey for grassland species during the migration, since grassland species are most commonly detected when they are flushed.

4.1.3 Cottonwood Treatment vs. Control

The effectiveness monitoring began in the year of planting for all revegetation treatments because it was not known in advance where these treatments would occur. A longitudinal multi-year analysis can be performed on these monitoring data to see if the site usage varies over time in response to the maturing revegetation treatments. For sedge treatments, it was not possible to define appropriate controls, and single year results have little context on their own. However, control plots could be defined for the cottonwood stake monitoring, and were included in the study, it is therefore possible to assess the effectiveness of this treatment annually without including multi-year time-series data.

In the year when the cottonwood stakes were first planted (2010), there was no significant detectable difference in migratory songbird use of cottonwood stake sites versus control sites (CBA 2010a). In 2011, additional cottonwood staking was conducted in spring, and we included several more treatment and control plots in the study. We did not analyze the raw data in this report, but we noted that the weekly averages of diversity and abundance of migrating songbirds in plots treated with cottonwood stakes were consistently greater than those observed in the control plots, and the odds of this occurring by chance is statistically significant. The effect size of this difference was very small. We expect that larger differences may be observed as the cottonwoods mature. The fact that our results already suggest evidence of habitat selection despite the small effect size, indicate that the sampling methods are adequate for detecting biologically important effects.

4.2 Random Plots and Habitat Selection

The identification of habitat preferences of migrating songbirds is the primary goal of the habitat use-availability component of this study, which was initiated in Year 1. Pilot analyses of Year 1 data suggested that this study will adequately meet its goal, and strong habitat/use associations were shown after one year of sampling (CBA 2009b). Sampling effort continued but was greatly reduced in Years 2 and 3 due to the large effort allocated towards effectiveness monitoring. In this report we provided a second pilot analysis of the date, this time including three years of random plot data.

4.2.1 Effort and Detections of Migrating Songbirds

The optimal sampling design will be one that has appropriately sized sampling plots, and which balances trade-offs between the number of plots sampled, and the duration of the sampling period at each plot in order to maximize the quantity and quality of data.

Selecting an appropriate plot size is a question of using plots that are large enough to detect target species, but not so large that only a proportion of the target species are detected. Our results demonstrate that the first criteria is met; there is a considerable diversity and number of target species that have been detected on plot in this study. Detection errors are likely to be very small in our study, because we monitor relatively small (50 x 50 m) plots.

Although the plot sizes used in this study appear to be appropriate, it is less obvious how to optimize the trade-off between the length of the sampling period and the number of plots sampled. This is particularly important in the design of repeated measures studies (e.g., at physical works sites). A sampling simulation can be performed on the random plot data to assess how modifying sampling period and number of samples impacts total diversity impacted each year (see **Recommendation 2** below). This analysis was beyond the scope of this report, but as we noted earlier, the 10 minute sampling period appears to be a sensitive method for the cottonwood stake study.

4.2.2 Habitat Strata, Plot Characteristics, and Habitat Selection

Data from three years of monitoring were relatively consistent in the relationships between the probability of detecting a migrating songbird on-plot and the habitat strata of the plot. Forest and shrub strata had high detection rates, grassland and unvegetated had low detection rates, and wetland plots had intermediate rates. The combined data, categorized as having one or more on-plot migrating songbirds detected, or not, showed highly significant variation among the habitat strata. These results can be used to provide rudimentary maps of habitat quality. In future analyses, other GIS layers could be introduced into a habitat selection model, including vegetation community maps and digital elevation models.

For the purposes of providing habitat management recommendations, data from this study can be used to test models predicting songbird occurrence as a function of plot characteristics. Plot characteristics are field data used to describe the habitat structure observed in the plot being sampled. These descriptors quantify vegetative layers throughout the entire 50 x 50 m plot, and are shown our results to be linked to bird detections. We fit some preliminary models to assess how the various vegetation types and layers influence the presence/absence of migrating songbirds, and these models consistently showed a negative influence of open habitat, and a positive influence of shrub, tall shrub, and tree layers. The relative proportions of willow versus cottonwood were not clearly related to the probability of detecting a migrating songbird; as such, the models presented in this report cannot be used to recommend planting willow over cottonwood, or visa versa – more detailed analyses are required.

The preliminary models presented in this report are overly simplistic and should not be considered final. First, theses models used a binary (presence/absence) response variable, ignoring considerable variability in the number of detections. A full analysis should consider modelling the abundance and diversity of birds detected using an appropriate distribution for count data (e.g., Poisson, negative binomial) or a zero-inflated model (e.g., a zero-inflated Poisson model, or the like). Second, a full analysis should consider using more predictor variables and including interaction terms. Third, General Additive Models can be used to control for non-linear effects such as seasonality, which may allow for greater resolution, and/or allow for more subtle effects to be detected. Finally, it may be worth using multi-variate models of species assemblage as a function of plot characteristics (e.g., canonical correspondence analysis), and/or build species-specific models for species that are detected in sufficient abundance (e.g., American Pipits or Yellow-rumped Warblers). Such analyses require considerably more time, and were beyond the scope of the current report. Nonetheless, the preliminary models provided supporting evidence that planting shrubs or trees should increase the value of habitats for migrating songbird during spring migration.

4.2.3 Timing of Migrations

In order to manage reservoir operations for migrating songbirds, it is not only necessary to understand which habitats in the drawdown zone are used by migrating songbirds, it is equally important to determine the timing of each species' migrations because the availability of habitats depend on the timing of reservoir operations. Pooling spring monitoring data from Year 1 (2009) to Year 3 (2011) provided a chronology of migration for different songbird species. Temporal patterns will continue to become clearer with additional years of data collection.

4.3 Concluding Remarks

In 2011 we completed the third year of monitoring spring songbird migration activity in the drawdown zone of Revelstoke Reach. Annual results have consistently indicated that drawdown zone habitats are well used by songbirds during the spring migration. In this report, we provided preliminary analyses showing that the number and diversity of songbirds detected varies among habitat types, and different habitats are used by different species. These results highlight the importance of habitat management, and the need to understand these relationships. In general, we have seen that shrubs and trees increase usage by migrating songbirds in the drawdown zone. Initiatives such as the cottonwood staking treatments can potentially alter habitat value for migrating songbirds, and this could help restore the habitat value of this region where much of the natural riparian habitat has been destroyed. Our effectiveness monitoring of these treatments is already showing evidence of a positive treatment effect. Additional years of monitoring will be required before full habitat selection models can be tested, and before detailed analyses of physical works treatments can be performed. Future monitoring of migrations using the techniques pioneered by CLBMON 11B-2 will occur under CLBMON 39 – a contract that is dedicated to monitoring songbird migrations in the spring and fall, and which will consider an expanded set of management questions.

4.4 Recommendations

4.4.1 Recommendation 1—Study Period

We recommend that random plot (habitat selection) sampling should start in early April or even mid March, at least in some years. As noted in two earlier reports, a sizable migration of Mountain Bluebirds moves through the drawdown zone in early April (CBA 2009b, 2010a). The early migrations through the drawdown zone are currently going undetected or are under-detected. Over time, migration monitoring should cover sampling over the entire spring migration period within all habitat strata. The habitat use-availability study will benefit from having a large number of samples in each habitat strata for every week of the sampling season. It was not possible to follow up on this recommendation in 2011, but CBA plans to satisfy this recommendation in 2012.

4.4.2 Recommendation 2—Validation

We recommend that the random plot data should be analyzed to simulate the effect of changing sampling period and the number of samples. Results from such an analysis will allow the trade-off between these parameters to be optimized for repeated measures sampling.

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6 APPENDICIES

Appendix 6-1: CLBMON 11B-2 Status of Objectives, Management Questions, and Hypotheses after Year 3

(EMC = Effectiveness Monitoring Components; HS = Habitat Selection). Note that HA_{1C}, HA_{1D}, HA_{1E}, HA_{2C}, and HA_{2D}, which are specified for other CLBMON 11B components, have no relevance for CLMBON 11B-2, and are not listed here.

Objectives	Management Questions	Management Hypotheses	Approaches	Status
Develop a monitoring program to assess the effectiveness of the revegetation program (CLBWORKS 2) and wildlife physical works projects (CLBWORKS 30) at enhancing wildlife habitat in the drawdown zone of Arrow Lakes Reservoir. Monitor the appropriate biological indicators and response variables to assess the effectiveness of the revegetation and wildlife physical works programs at enhancing wildlife habitat in the drawdown zone.	Are the revegetation and the wildlife physical works projects effective at enhancing wildlife habitat in the drawdown zone? If so, To what extent does the revegetation program and the wildlife physical works projects increase the productivity of habitat in the drawdown zone for wildlife?	**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_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_3**: The methods and techniques employed do not result in changes to wildlife habitats in the Arrow Lakes Reservoir drawdown zone. **HA_{3A}**: The vegetation 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.	EMC (HS)	EMCs were initiated in 2010 for three revegetation treatments to test **HA_1**, **HA_{1A}**, **HA_{1B}**, **HA_3**, and **HA_{3A}**. All of the components are long-term monitoring studies, and no issues have been identified. An EMC was initiated in 2010 for WPW6A to test **HA_2**, **HA_{2A}**, **HA_{2B}**, **HA_3**, and **HA_{3B}**. This study requires one more years of monitoring the footprint area after the completion of this habitat modification. Additionally, monitoring of the Airport Marsh, which is protected by this project, will continue as part of the HUA approach on an annual basis. No issues have been identified. An EMC designed for WPW14/15A consisted of a large plot-based effort in 2010 to monitor the usage of terrestrial habitats that will be impounded by this project. Field data collection for the EMC has been completed, but full analysis will not be conducted until Year 5. No issues have been identified.

Provide recommendations on the effectiveness of the revegetation program and wildlife physical works projects on improving habitat for wildlife in the drawdown zone.	Are some methods or techniques more effective than others at enhancing wildlife habitat in the drawdown zone?	None specified	HS EMC	All EMC results will be compared in Year 5 and Year 10 to address this Management Question. However, the scope for current EMC's to provide recommendations is limited for this Objective. To address this Objective, the HUA study is monitoring a full range of reservoir-tolerant habitats, and analyses will provide quantitative results from which recommendations can be made. Progress is satisfactory, and no issues have been identified.

Appendix 6-2: Observed migrating songbird species at four permanent effectiveness monitoring plots at WPW6A

Common Name	Scientific Name	On-plot	Overhead	Total
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	0	3	3
Marsh Wren	*Cistothorus palustris*	1	0	1
American Pipit	*Anthus rubescens*	42	74	116
Yellow-rumped Warbler	*Dendroica coronata*	8	14	22
Common Yellowthroat	*Geothlypis trichas*	1	0	1
Savannah Sparrow	*Passerculus sandwichensis*	3	9	12
Unidentified sparrow	*Emberizidae* (spp.)	0	25	25
Pine Siskin	*Spinus pinus*	0	6	6
All species		55	131	186

Appendix 6-3: Number of migrating songbirds encountered during the Cartier Bay transects, listed by species and by the distance zones of their detections (1 ≤ 1 m from shore, 5 ≤ 5 m from shore, etc.). Only birds that landed on the ground are included

Week	Date	Zone	Species	Number
1	2011-04-28	1	American Pipit	27
1	2011-04-28	1	Savannah Sparrow	1
1	2011-04-28	5	American Pipit	31
1	2011-04-28	5	Savannah Sparrow	1
1	2011-04-28	10	American Pipit	24
1	2011-04-28	10	Unidentified sparrow	5
1	2011-04-28	> 10	American Pipit	102
2	2011-05-03	1	American Pipit	114
2	2011-05-03	1	Savannah Sparrow	1
2	2011-05-03	5	American Pipit	129
2	2011-05-03	10	American Pipit	203
2	2011-05-03	10	Savannah Sparrow	1
2	2011-05-03	> 10	American Pipit	151
3	2011-05-13	1	American Pipit	70
3	2011-05-13	5	American Pipit	26
3	2011-05-13	10	American Pipit	18
3	2011-05-13	> 10	American Pipit	67
4	2011-05-19	5	American Pipit	7
4	2011-05-19	> 10	American Pipit	7
5	2011-05-25	> 10	American Pipit	12
6	2011-06-02		none	0
7	2011-06-08		none	0

Appendix 6-4: Observed migrating songbird species at 12 permanent effectiveness monitoring subplots at a site revegetated with water sedge plugs

Common Name	Scientific Name	On-plot	Overhead	Total
Eastern Kingbird	*Tyrannus tyrannus*	0	3	3
Tree Swallow	*Tachycineta bicolor*	0	25	25
Violet-green Swallow	*Tachycineta thalassina*	0	3	3
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	0	8	8
Unidentified swallow	*Hirundidae* (spp.)	0	17	17
American Robin	*Turdus migratorius*	1	5	6
American Pipit	*Anthus rubescens*	156	34	190
Yellow-rumped Warbler	*Dendroica coronata*	2	1	3
Savannah Sparrow	*Passerculus sandwichensis*	3	0	3
White-crowned Sparrow	*Zonotrichia leucophrys*	0	6	6
Dark-eyed Junco	*Junco hyemalis*	0	1	1
American Goldfinch	*Spinus tristis*	0	3	3
Unidentified songbird		0	1	1
All species		162	107	269

Appendix 6-5: Observed migrating songbird species at 11 permanent effectiveness monitoring control plots that were not revegetated with cottonwood stakes

Common Name	Scientific Name	On-plot	Overhead	Total
Tree Swallow	*Tachycineta bicolor*	0	9	9
Violet-green Swallow	*Tachycineta thalassina*	0	1	1
Barn Swallow	*Hirundo rustica*	0	1	1
Unidentified swallow	*Hirundidae* (spp.)	0	9	9
Townsend's Solitaire	*Myadestes townsendi*	2	1	3
American Robin	*Turdus migratorius*	4	13	17
American Pipit	*Anthus rubescens*	0	21	21
Cedar Waxwing	*Bombycilla cedrorum*	0	4	4
Yellow-rumped Warbler	*Dendroica coronata*	0	33	33
Yellow-rumped (Audubon's) Warbler	*Dendroica coronata auduboni*	7	4	11
Savannah Sparrow	*Passerculus sandwichensis*	2	0	2
White-crowned Sparrow	*Zonotrichia leucophrys*	1	10	11
Unidentified sparrow	*Emberizidae* (spp.)	0	1	1
Brown-headed Cowbird	*Molothrus ater*	0	4	4
Pine Siskin	*Spinus pinus*	0	2	2
American Goldfinch	*Spinus tristis*	0	3	3
Evening Grosbeak	*Coccothraustes vespertinus*	0	5	5
Unidentified songbird		0	5	5
All species		16	126	142

Appendix 6-6: Observed migrating songbird species at 16 permanent effectiveness monitoring plots that were revegetated with cottonwood stakes

Common Name	Scientific Name	On-plot	Overhead	Total
Warbling Vireo	*Vireo gilvus*	1	0	1
Tree Swallow	*Tachycineta bicolor*	0	9	9
Violet-green Swallow	*Tachycineta thalassina*	0	8	8
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	0	9	9
Barn Swallow	*Hirundo rustica*	0	1	1
Unidentified Swallow	*Hirundidae* (spp.)	0	21	21
Mountain Bluebird	*Sialia currucoides*	4	0	4
Townsend's Solitaire	*Myadestes townsendi*	1	0	1
American Robin	*Turdus migratorius*	7	13	20
European Starling	*Sturnus vulgaris*	0	12	12
American Pipit	*Anthus rubescens*	0	29	29
Cedar Waxwing	*Bombycilla cedrorum*	0	23	23
Yellow Warbler	*Dendroica petechia*	0	1	1
Yellow-rumped Warbler	*Dendroica coronata*	30	8	38
Yellow-rumped (Audubon's) Warbler	*Dendroica coronata auduboni*	22	34	56
Common Yellowthroat	*Geothlypis trichas*	1	0	1
Chipping Sparrow	*Spizella passerina*	7	1	8
Savannah Sparrow	*Passerculus sandwichensis*	10	5	15
White-crowned Sparrow	*Zonotrichia leucophrys*	0	15	15
Unidentified sparrow	*Emberizidae* (spp.)	1	12	13
Western Meadowlark	*Sturnella neglecta*	1	3	4
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	0	1	1
Brewer's Blackbird	*Euphagus cyanocephalus*	0	1	1
Brown-headed Cowbird	*Molothrus ater*	1	5	6
Red Crossbill	*Loxia curvirostra*	0	2	2
Pine Siskin	*Spinus pinus*	0	1	1
American Goldfinch	*Spinus tristis*	0	2	2
Evening Grosbeak	*Coccothraustes vespertinus*	0	3	3
All species		86	219	305

Appendix 6-7: Total number of migrating songbirds detected at random plots in 2011

Common Name	Scientific Name	Off-plot	Overhead	On-plot	Total
Least Flycatcher	*Empidonax minimus*	2			2
Dusky Flycatcher	*Empidonax oberholseri*	4			4
Cassin's Vireo	*Vireo cassinii*	3			3
Warbling Vireo	*Vireo gilvus*	4		2	6
Tree Swallow	*Tachycineta bicolor*	18	64	2	84
Violet-green Swallow	*Tachycineta thalassina*	3	20		23
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	31	30		61
Cliff Swallow	*Petrochelidon pyrrhonota*	1	1		2
Barn Swallow	*Hirundo rustica*		10		10
Winter Wren	*Troglodytes hiemalis*	1			1
Marsh Wren	*Cistothorus palustris*	2			2
Ruby-crowned Kinglet	*Regulus calendula*	6		6	12
Mountain Bluebird	*Sialia currucoides*	10		1	11
Veery	*Catharus fuscescens*	1			1
Swainson's Thrush	*Catharus ustulatus*	1			1
American Robin	*Turdus migratorius*	15		3	18
Varied Thrush	*Ixoreus naevius*	1			1
Gray Catbird	*Dumetella carolinensis*			1	1
American Pipit	*Anthus rubescens*	48	78	63	189
Cedar Waxwing	*Bombycilla cedrorum*		1	14	15
Orange-crowned Warbler	*Oreothlypis celata*	8			8
Yellow Warbler	*Dendroica petechia*	13		3	16
Yellow-rumped Warbler	*Dendroica coronata*	52	9	32	93
Townsend's Warbler	*Dendroica townsendi*			1	1
American Redstart	*Setophaga ruticilla*	5			5
MacGillivray's Warbler	*Oporornis tolmiei*			1	1
Common Yellowthroat	*Geothlypis trichas*	26		2	28
Wilson's Warbler	*Wilsonia pusilla*	1			1
Chipping Sparrow	*Spizella passerina*	12		7	19
Savannah Sparrow	*Passerculus sandwichensis*	14	46	27	87
Song Sparrow	*Melospiza melodia*	8			8
Lincoln's Sparrow	*Melospiza lincolnii*	2		4	6
White-crowned Sparrow	*Zonotrichia leucophrys*	3		10	13
Dark-eyed Junco	*Junco hyemalis*	1			1
Western Tanager	*Piranga ludoviciana*	2			2
Red-winged Blackbird	*Agelaius phoeniceus*	11	4	5	20
Western Meadowlark	*Sturnella neglecta*	4			4
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	13		1	14
Brown-headed Cowbird	*Molothrus ater*	11	3		14
Bullock's Oriole	*Icterus bullockii*	1			1
White-winged Crossbill	*Loxia leucoptera*	2			2
Pine Siskin	*Spinus pinus*	33	47	10	90
American Goldfinch	*Spinus tristis*	5	5		10
Unidentified birds		16	8		24
Total		394	326	195	915