Columbia Wetlands Marsh Bird Monitoring Project (CWMBMP)

Final Report

Project No. COL-F19-W-2677

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Prepared for Fish and Wildlife Compensation Program

Prepared with financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and public stakeholders.

26-Feb-2019

Executive Summary

Marsh birds are inconspicuous and difficult to detect, consequently sparse worldwide data exists relating to marsh bird species, including population status. Global reports however do suggest that many marsh bird species population status are in decline. The Columbia Wetlands Marsh Bird Monitoring Project (CMMBMP) used a standardised protocol to conduct repeated point count surveys at 65 survey stations. The protocol uses call-back recordings to elicit a response from marsh bird species in the area, increasing the detection rate for marsh birds. Focal birds for this project are the American bittern (*Botaurus lentiginosus*), Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), pied-billed grebe (*Podilymbus podiceps*), and American coot (*Fulica americana*).

This project is anticipated to run for three-years (2017-2019) allowing for a compilation of baseline inventory data that will be sequentially used to estimate marsh bird populations in the Columbia Wetlands, as well as assess target species distribution, and identify significant breeding areas or habitat types in the wetlands. Data from the CWMBMP have been used to formulate management recommendations for habitat-based conservation projects including establishment of a Wildlife Habitat Area for an at-risk species, wetland restoration, and the installation of nesting boxes in areas where marsh bird breeding habitat is limited.

The CWMBMP aligns with two Fish and Wildlife Compensation Program (FWCP) Columbia Region priorities: 1) involvement in implementation of riparian and wetland restoration and, 2) conservation activities, delivered in the region of the North Columbia. The CWMBMP also aligns with two FWCP action plans: 1) the Riparian and Wetlands Action Plan (habitat-based actions, monitoring and evaluation) and, 2) the Species of Interest Action Plan (research and information acquisition). This particular project (study) collects data used to look at the distribution and form abundance estimates for marsh bird species in wetland and riparian areas of the Columbia Wetlands ecosystem.

The CWMBMP has developed partnerships with several relevant organizations sharing mutual interests in management and preservation of marsh birds, and wetland enhancement and conservation [e.g. Canadian Wildlife Service (CWS), Ducks Unlimited Canada (DUC), and Canadian Intermountain Joint Venture (CIJV)]. Additionally, the project has been designed to engage community members of the North Columbia, increasing their ecological appreciation of wetlands and birds through volunteer opportunities to assist a biologist in the field.

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Introduction

Background

Marsh bird species are elusive and inconspicuous with cryptic coloration, making them difficult to detect. Accordingly, minimal data has been collected and little is known about most marsh bird species, including information on their behaviour, population status, or distribution. Information on status and population trends of marsh birds in the western mountains region has been previously identified as a gap, noted in the final report of the Avian Monitoring Review (Avian Monitoring Review Steering Committee, 2012). Abundance estimates and trend data for secretive marsh species in North America, such as Virginia rail (*Rallus limicola*) and sora (*Porzana carolina*), are largely unavailable but recent efforts to collect inventory data on marsh birds have reported population declines continentally and globally for a number of species (Conway, 2011). The horned grebe (*Podiceps auritus*) was recently up-listed to vulnerable (globally threatened) on the International Union for Conservation of Nature's (IUCN) Red List due to the effects of human disturbance, including forestry operations and fluctuating water levels (Birdlife International, 2015).

Since approximately 1900 AD, 50% of the world's wetlands have been lost (Davidson, 2014) with marsh bird species dependent upon these habitats for breeding and other critical life stages. Wetlands comprise about 5.28 million hectares of British Columbia, with the expectation that this province may hold important populations of secretive marsh bird species using these habitats. However minimal baseline data has been compiled to date supporting that premise.

The Columbia Wetlands Marsh Bird Monitoring Project (CWMBMP) is a three-year project (2017-2019) that has been collecting baseline data on marsh birds in a significant and continuous wetland system located in southeastern British Columbia. To assist in alleviating data gaps on marsh bird populations, Goldeneye Ecological Services (GES) (a private company owned and operated by the principal author), in collaboration with the Population Assessment Unit of the Canadian Wildlife Service (CWS), initiated the pilot CWMBMP in 2016 (Darvill, 2018). Through this pilot project, a series of surveys were conducted for wetland-associated birds in the Columbia River Valley of British Columbia during the breeding season. This pilot project was initiated to develop and test a monitoring project that would be used to address information deficiencies for marsh birds. Due to time and funding resource constraints of the pilot project, 31 survey stations were initially established at relatively easy-to-access wetland locations. To augment habitat representation of the entire Columbia Wetlands ecosystem (leading to a more robust data set), FWCP seed funding was secured in 2017 to scout and determine the feasibility of conducting repeatable marsh bird surveys at remote locations of the Columbia Wetlands using kayaks and the involvement of volunteers. In total, 58 monitoring stations were established in 2017; 22 of those in relatively remote locations of the wetlands accessible by kayak.

The availability of suitable wetland breeding habitat fluctuates yearly with weather conditions through resultant annual changes in emergent vegetation, water depth fluctuations, wetland size and

connectivity, salinity, and food availability (Ma, Cai, Li, & Chen, 2009). These changing conditions dictate that information on marsh bird abundance is needed for multiple successive years to provide a robust baseline data set for secretive marsh birds of the Columbia Wetlands. This continuation of data acquisition in 2018 will be supplemented with a final year of data collection to be completed in 2019.

Data needed to inform management recommendations

It is challenging for various stakeholder agencies to assess where priority areas are for breeding populations of marsh birds, or how to maintain or enhance them, without first gathering baseline information. Monitoring data supports conservation initiatives and can prompt better land and water use planning initiatives to be observed in the Columbia Wetlands. A lack of data means critical habitat units cannot be accurately identified for marsh birds, nor can threats be properly assessed; suggesting that management recommendations and decisions may be less effective and possibly deleterious relating to any forthcoming recommendations concerning the conservation of critical marsh bird habitat in the Columbia Wetlands.

Although widely recognized as providing important habitat for numerous fish and wildlife species, many of which are imperiled (BC FLNRORD, n.d.; Environment Canada, 2014; Harrison, et al., 2010; Kaiser, McKelvey & Smith, 1977), minimal current marsh bird data is available for the Columbia Wetlands. The existent bird data previously gathered for the wetlands did not focus on marsh bird species, with existent studies further complicated with use of inconsistent methodologies to collect the data on record (e.g. Caspell et al., 1979; Cooper & Beauchesne, 2003; Demarchi & Smith, 1967; Kaiser, McHelvey & Smith, 1977). This deficiency of inconsistent documentation results in the inability of agencies to responsibly monitor bird species population, abundance and distribution trends.

Other than Wildsight Golden's Columbia Wetlands Waterbird Survey (CWWS) data set, a citizen-science initiative launched by the principal author in 2015 (Darvill, 2017), there have been no recent surveys for breeding or migrating waterbirds or waterfowl occurring in the Columbia Valley. To the best of our knowledge, there has only been one targeted survey for a marsh bird species [i.e. American bittern (*Botaurus lentiginous*)], in the Columbia Valley. This survey was conducted in a low water year and only two bitterns were detected in the Columbia Wetlands, both near Parson (Cooper & Beauchesne, 2003). The CWMBMP has detected bitterns in other areas of the Columbia Wetlands. The American bittern remains on British Columbia's blue-list, identifying it as a species of special concern in the province (B.C. Conservation Data Centre, 2019).

2018 Project Objectives

In 2018, GES continued to operate in collaboration with Canadian Wildlife Service (CWS) to complete year two (excluding the pilot year of 2016) of the anticipated three-year CWMBMP. The objectives of the 2018 project were to: a) collect the second year of baseline inventory data on marsh birds in the Columbia Wetlands, b) use resulting data to assess distribution and estimate marsh bird species

abundance in the Columbia Wetlands for select Fish & Wildlife Compensation Program (FWCP) priority and inventory bird species, as well as Canadian Intermountain Joint Venture (CIJV) priority birds, and c) utilize and engage private landowners and volunteers whom are living in the North Columbia sub-region, a priority region for the FWCP. Resulting data and analysis are being used to determine where the most important wetland habitat areas or habitat types are for breeding marsh birds so that management, preservation, enhancement and restoration efforts can be directed most effectively. In December 2019, data will be used to nominate the Columbia Wetlands to become part of the Important Bird and Biodiversity Area (IBA) initiative, a global program that works to identify, conserve and monitor a network of sites that provide essential habitat for birds (Bird Studies Canada, n.d.).

Project linkages to FWCP action plans

The 'Riparian and Wetlands Action Plan' is the primary Columbia Action Plan that the CWMBMP aligns with most closely. This is a 'habitat-based action' project with the following FWCP priority actions: 1) "monitor wildlife species presence and abundance in wetland and riparian areas in each focal area", 2) "explore options to collaborate with partners, in order to conserve and enhance wetland and riparian areas", 3) "implement program to monitor population trends of species in wetland and riparian areas including but not limited to amphibian" (BC Hydro, 2014*)*. This project was implemented to monitor population trends of approximately 110 marsh bird species in the Columbia Wetlands. The project collects inventory data that will enable monitoring of marsh bird species presence and abundance in the Columbia Wetlands. The CWMBMP has developed partnerships with agencies (i.e. Canadian Wildlife Service) that will assist in evaluation and extrapolation of inventory data, leading to population estimates for the entire wetlands system. It is anticipated that management recommendations will lead to future project implementation to enhance habitat that will maintain or increase the carrying capacity of the wetlands for marsh birds. Project involvement also includes landowner outreach visits with rural landowners (in North Columbia), to determine priority projects to restore degraded riparian/wetlands.

The CWMBMP also aligns with the 'Species of Interest Action Plan.' The priority action from this plan is: "Inventory species are those for which inventory / data acquisition is the primary compensation action identified by FWCP staff and technical committees and in the Columbia Basin dam impacts reports (e.g. Manley & Krebs, 2009)." "Before further actions are developed and implemented, some baseline inventory work is required for these species to determine their distribution and abundance and/or trend within the Columbia Basin" (BC Hydro, 2012). This project collects data and monitors trends of 37 FWCP Inventory Species and 9 FWCP Focal Species in wetland and riparian areas of the Columbia Wetlands (Appendix 1). This project will assist in the design and direction of future conservation initiatives in the North Columbia sub-region around Golden so that limited conservation funds will be used more effectively for preservation and enhancement of marsh bird habitat This project takes place in North Columbia, an area which has been identified by the FWCP as a priority region to deliver funding.

Study Area

The Columbia Wetlands (51.593984; -116.282094) are a continuous wetland ecosystem centred on the Rocky Mountain Trench from Canal Flats to Donald north, and include both Lake Windermere and Columbia Lake. The total length is approximately 180 kilometers and the wetlands cover over 26,000 hectares (Pedology Consultants, Quadra Economic Consultants Ltd, Robinson Consulting & Associates Ltd., and Glen Smith Wildlife Resource Consultant Ltd., 1983). The wetlands are in a valley-bottom with several adjacent communities (e.g. Golden, Parson, Brisco, Radium, Invermere). The CWMBMP survey stations extend from the north end of Columbia Lake to Golden in the north (Figure 1). Additionally, five higher elevation wetland sites were used as survey stations, but are not located in the continuous Columbia Wetlands ecosystem and as such were not used in the abundance analyses provided in this report.

Approximately half of the Columbia Wetlands reside within the Regional District of East Kootenay (RDEK) Area's F and G, with the remaining half within the Columbia Shuswap Regional District (CSRD) Area A's jurisdiction. Much of the wetlands are designated as the Columbia Wetlands Wildlife Management Area (WMA) with additional conservation parcels, and a significant amount of private land (31.8%) included within this ecosystem (BC Hydro, 2014). While the WMA status is important for conservation, the International Union for the Conservation of Nature (IUCN) Protected Areas Categories states that this type of conservation area (i.e. VI: Managed Resource Protected Area) offers the lowest form of protection for a conservation area (IUCN, 2017). The entire wetland ecosystem and its habitat value to birds remain under cumulative stress from a variety of threats including climate change, (expected to have broad and negative impacts across Bird Conservation Region 10: Northern Rockies where the Columbia Wetlands are located); and particularly in alpine and wetland habitats where it is anticipated that there will be more fluctuating water levels due to severe weather events (Environment Canada, 2013).

Anthropogenic pressures continue to be significant in the Columbia Valley, as it is a valley-bottom and transportation corridor with large tracts of agricultural land. Agriculture, while undoubtedly valuable to humans, is an ongoing concern for wetland health and integrity. Water extraction for irrigation can reduce flows and the use of fertilizers may pollute or add unwanted nutrients to the wetlands. Livestock grazing adds additional extraneous nutrients to water, promotes invasive species introductions, removes wetland vegetation, and compacts soils (Harrison et al., 2010). Kaiser, McKelvey & Smith (1977) reported that a slough in Brisco became eutrophic due to agriculture and domestic effluent. Livestock trampling of riparian and emergent vegetation is also problematic in the Columbia Wetlands (Figures 2 and 3). Emergent vegetation in wetlands is essential for marsh birds as it is required for nest building material and for food during migration and breeding (Environment Canada, 2013).

There are existent surrounding land use pressures with increasing rural, urban and industrial development; including ongoing forestry projects, wood mill processing yards and other commercial

enterprises. Furthermore, within the CSRD portion of the Columbia Wetlands there is an absence of zoning, building restrictions or bylaws in place. Ecological protection is further complicated by the absence of any Riparian Area Regulations as a consequence of a non-existent Official Community Plan.

Levels of recreational use continue to increase in the wetlands and while there are specific restrictions in place on motorized vessels in the Columbia Wetlands (in part to help protect significant bird habitat), (Government of Canada, 2016), there are no current limits or restrictions on non-motorized recreational use. With the recently concluded Golden Recreational Trails Strategy process, increasing pressures on the Columbia Wetlands were identified. For instance, some individuals and businesses residing in the area have expressed interest in further expanding the recreational opportunities in the wetlands, e.g. more canoe/paddle tours, more river access points, and designated camping areas (J. Jones, personal communication, October 2017).

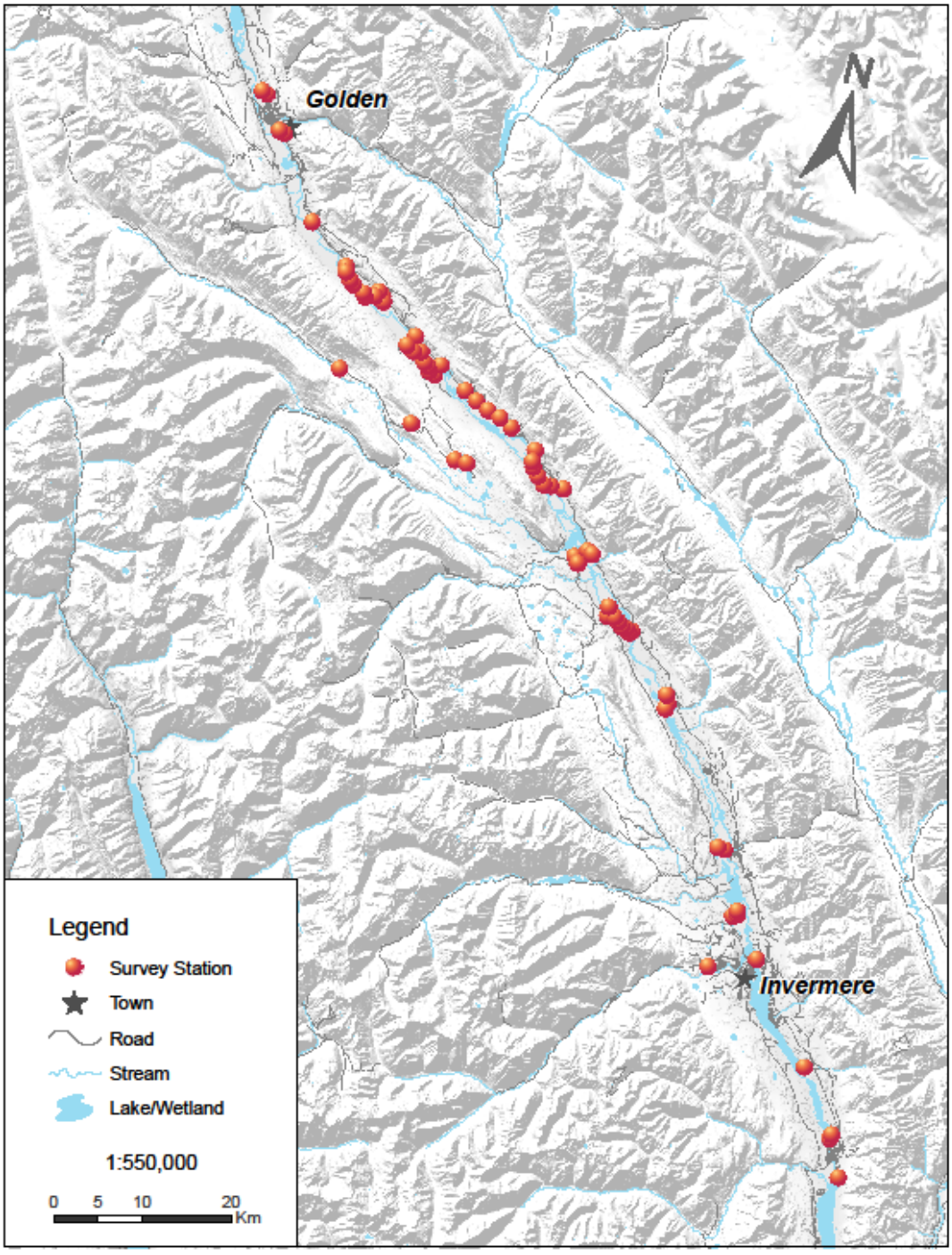

Figure 1. Map depicting the locations of the 65 marsh bird monitoring survey stations within the Columbia Valley study area.

Figure 2. Cattle as observed in the Columbia Wetlands on November 25, 2017.

Figure 3. Cattle as observed in the Columbia Wetlands on October 15, 2018.

Methods

Point counts

The 2018 marsh bird surveys utilized 65 survey stations to conduct point counts, including the 36 survey stations previously established during the 2016 pilot project (accessed by vehicle and/or walking), 22 stations established in 2017, as well as seven new stations established in 2018. Five of the survey stations were located at higher elevation lakes (Bittern Lake, marsh near Mitten Lake, Wilbur Lake, Loon Lake, Lillian Lake), with the majority of the survey stations located within the continuous Columbia Wetlands ecosystem. Stations were selected to cover a wide diversity of habitat conditions in the Columbia Valley and to represent the overall landscape. Google Earth Pro (Version 7.3.0.3832) was utilized to visually plan access points and survey routes, which consisted of 3-8 survey stations. Survey stations were selected along survey routes based upon accessibility, but were also selected to be at least 500 meters apart to avoid double counting birds.

A standardized method for counting marsh birds was used as a basis for conducting the surveys; the Prairie and Parkland Marsh Monitoring Program Manual developed by Bird Studies Canada (BSC) (2010). Each survey was conducted in the morning by one primary observer per station, who was often accompanied by a volunteer. The surveys began no earlier than 30 minutes before sunrise and ended no later than 10:00 am on each survey date (BSC, 2010). Each station was visited two to three times during the breeding season (May 11-June 28th), for a total of 191 marsh bird surveys. Surveys were conducted only when weather conditions were favorable, e.g. no precipitation, minimal wind, good visibility. If weather conditions were not favorable, or turned unfavorable partway through a survey route, the remaining surveys were postponed and conducted on another day.

Secretive and inconspicuous marsh birds are better detected using broadcast equipment, rather than using visual detection alone (Conway, 2011). Recent studies report that there is a significant increase in the number of marsh birds detected when using call-broadcasting equipment to assess occupancy and estimate population trends (Conway & Nadeau, 2010) and this methodology was used in the CWMBMP. During each point count, a primary observer stood at a central location (Figure 4) and used a 5-minute silent/listening period, followed by a 5-minute period during which calls of selected focal species [sora, Virgina rail, American bittern, American coot (*Fulica americana*), pied-billed grebe] were played using broadcast equipment (FoxPro Firestorm). This was followed by another 5-minute silent/listening period. During the 15-minute survey, observations (visual and/or aural) of all bird species detected within a 100 meter radius were recorded. All birds observed were recorded in one of four categories: focal species, primary species, secondary species, and additional species (Appendix 1). Focal species were monitored minute-by-minute during the listening period. All additional bird species present were recorded, but not followed minute-by-minute. Observations of birds were also recorded beyond the 100 meter radius, but those birds were recorded as occurring outside of the focal area. If a secondary species occurred outside the focal area, it was indicated as present at the station, but the number of individuals was not recorded. Also, for all 'additional species' observed inside or outside the focal area, presence was

indicated, but those individuals were not counted. Both male and females were recorded for all species, with the exception of red-winged blackbird (*Agelaius phoeniceus*) and yellow-headed blackbird (*Xanthocephalus xanthocephalus*). In the case of these two species only the males were recorded as those blackbird species are polygamous and there are often too many females to track accurately (BSC, 2010).

Habitat surveys occurred at each station and were completed after the final round of bird surveys in order to minimize disturbance and avoid the compromise of data collection on the marsh birds themselves [North American Marsh Bird Monitoring Program (NAMBMP), 2009)]. The habitat monitoring protocol for marsh bird surveys was suggested and provided by the Canadian Wildlife Service (NAMBMP, 2009). The habitat monitoring protocol involved recording the dominant vegetation and habitat types surrounding the survey point, including percent coverage (or dominant, sub-dominant) of wetlands plants that are within 100 meters of the survey point. All data was entered into the excel database required by CWS, as well as transcribed into the Species Inventory (SPI) provincial data warehouse that is available online.

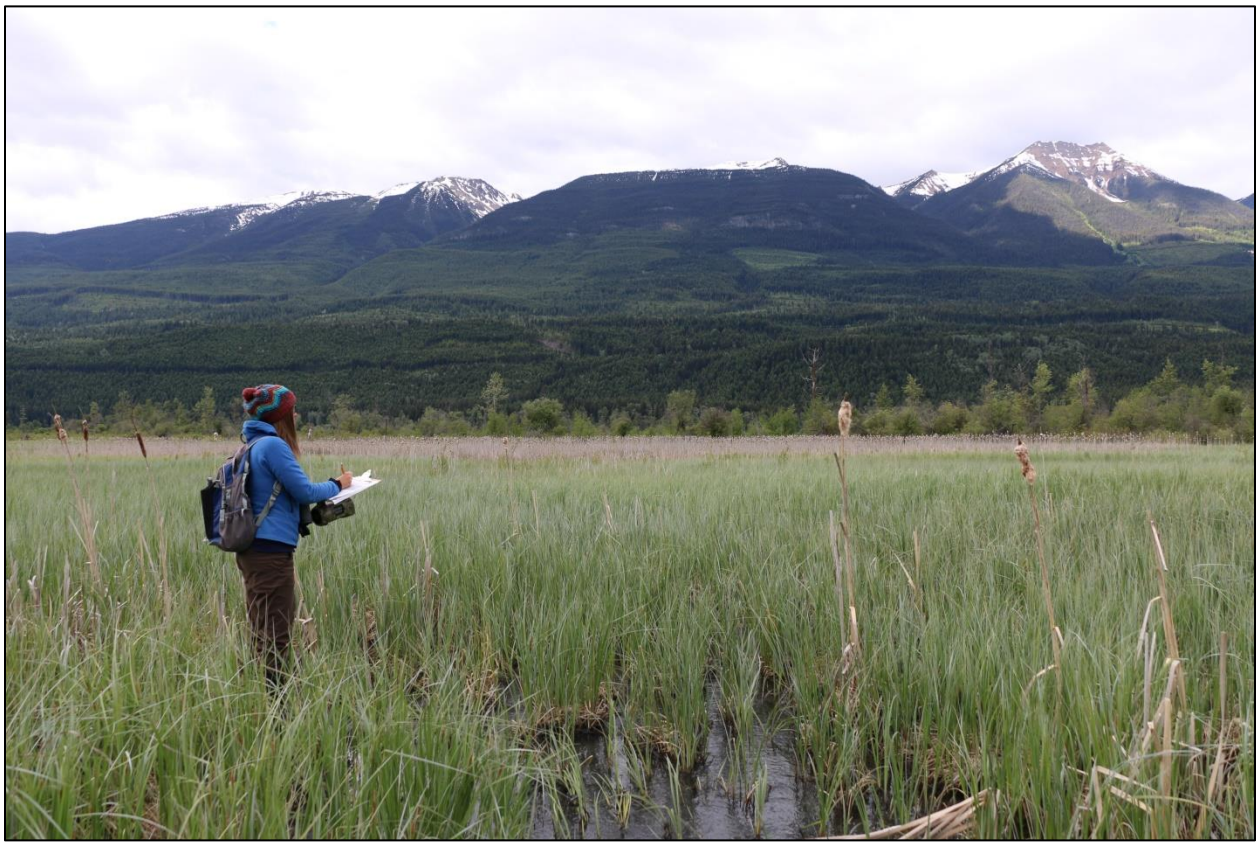

Figure 4. Project biologist conducting a marsh bird survey from a survey station located in the Columbia Wetlands at Birchlands Creek.

Volunteer recruitment and landowner engagement

Volunteer recruitment used the following communication methods: poster distribution (30), presentations (5), social media, and advertisements placed in 'The Golden Star' newspaper and 'Wings Over the Rockies' festival guide (Appendix 2). There were ample opportunities for volunteers to participate in marsh bird data collection. Community engagement (presentations), volunteer opportunities, and landowner outreach mainly took place within the FWCP priority North Columbia sub-region (i.e. Golden and surrounding area), which expanded educational engagement opportunities with interest groups in that priority region.

Forming abundance estimates from 2016-2018 CWMBMP data

Estimating abundance requires two key components: estimates of 1) the area included in the estimation, and 2) the density of the population of interest. To address the first requirement, thorough habitat assessments of the Columbia Wetlands were published by Pedology Consultants et al. (1983). For our purposes, we considered habitat Pedology Consultants et al. (1983) classified as marsh, which was flooded periodically or year-round, to be suitable habitat for our species. Pedology Consultants et al. (1983) concluded that approximately 9,220 hectares of marsh habitat are present in the Columbia Wetlands. Habitat assessments of the Columbia Wetlands have not been completed on the same scale since this 1983 report, therefore updated information with this level of detail is not available. We acknowledge that changes have potentially occurred since these surveys took place but felt that changes that have occurred to marsh area are likely to be relatively small and pose little issue for our estimates. Addressing the second requirement regarding a density estimate can be more challenging, particularly for species which are secretive in nature. Observing a bird during a survey requires two conditions be met: 1) the species is present, and 2) the species was observed during the survey. Not observing a species, however, results from one of two scenarios: 1) the species is in fact not present, which is called a "true zero", or 2) the species is present but was not observed, which is called a "false zero". Given the secretive nature of the target species, the risk of acquiring many of these "false zeros" and underestimating species density remains a significant consideration. Distance sampling methods, (where distance from the observer is estimated as part of an observation,) can be used to account for imperfect detection (i.e. the accumulation of "false zeroes"). It does so by relating distance from the observer to the probability of detecting a species of interest. This can be refined further by including other relevant variables which could affect this probability into a model, such as habitat characteristics. This model can then be used to estimate the true species density at each survey station.

It is important to note that some bird observations were not included in calculating abundance estimates for focal and primary marsh birds. Only observations which occurred within the 15-minute survey window were included in estimating abundance. Exclusion of the observations outside the 15-minute window was done to minimize bias by ensuring that the survey effort was maintained across all visits. In a few rare instances, the distance between the observer and the bird was not recorded during the survey. These observations were also not included in estimating abundance, as this value is

necessary to produce the estimates, but are included in the total detections in each season. Five higher elevation lake stations, between 939 and 1,295 meters, were also surveyed but not included in the abundance estimate analyses. Few observations of species of interest were typically recorded at these stations and those stations represent elevations dramatically different than the survey stations in the Columbia Wetlands. Therefore, we did not conclude that data from higher elevation wetlands/lakes would contribute meaningfully to our analyses.

Abundance estimates (used to estimate the number of individuals in a population) of focal and primary species were completed using 2016-2018 CWMBMP data and by using Distance 7.2 Windows package (Thomas et al., 2010). Excel spreadsheets for each species containing station names, survey effort, year, observations, and habitat variables were converted to tab-delimited text files and loaded into Distance 7.2. Input was analyzed separately by year and species. Observations were defined as binned distances in the following categories: 0-50 meters, 50-100 meters, and 100-300 meters. Following the approach recommended by Buckland et al. (2001), we selected a key function followed by a series expansion. Models using the key function "Half-normal" and series expansion "cosine" outperformed those using "Hazard-rate" or "Uniform" functions in most cases. For species that had less than 30 observations per season, models using the "Uniform" function tended to perform best. Habitat variables were incorporated as co-variates to explore more complex models. To assess model fit, Buckland et al. (2001) recommend maximum likelihood methods using Akaike Information Criterion (AIC and AICc, which is the AIC corrected for small sample sizes). AIC and AICc assess how much information is gained or lost by a model in order to estimate the quality of each model relative to others. Once a full set of models were run, model-averaged estimates were calculated from the output. These were calculated using the Akaike weight, the relative likelihood of a given model in a set of models being correct. Akaike weights can be used to produce a weighted average for each parameter.

A range of habitat variables were collected to learn more specifics regarding habitat selection by breeding marsh bird species. Based on local expertise and a literature review, a set of habitat variables were selected to be incorporated into the Distance 7.2 models (Table 1). These variables were used to see if they improved model quality and produced more accurate abundance estimates. Seasonal timing is frequently considered in the literature, though its importance and effects vary between species (Harms & Dinmore, 2014; Tozer, Drake, & Falconer, 2016). Some species may be more likely to be observed earlier in the season, whereas others may arrive and be observed later. We examined seasonal timing at fine- and coarse-scales to account for a range of sensitives different species may have. We used "day since 1 May" (e.g. a survey on 10 May would be day 10) as a fine-scale measure and "visit" (i.e., visit 1, 2, or 3) as a coarse-scale measure of seasonal timing. "Day since May 1" allowed us to consider day-by-day differences of when observations take place, whereas "visit" considers the breeding season divided into three, broad time windows. These two variables were not considered together in the same model as they are similar measures of seasonal timing. Woody vegetation can be negatively correlated with some marsh bird species (Bolenbaugh, Krementz, & Lehnen, 2011; Nielson, 2016) and could explain species absence or low detection frequency. Emergent vegetation is frequently correlated with a variety of marsh bird species in the literature (Bolenbaugh et al., 2011; Fairbairn & Dinsmore, 2001; Lor & Malecki, 2006; Baschuk, Koper, Wrubleski, & Goldsborough, 2012) and has strong ecological

relevance. Two variables were considered separately for emergent vegetation: 1) total percent cover of emergent vegetation and 2) percent cover of "tall" emergent vegetation only, cattail (*Typha* spp.) and rushes (*Juncus/Scirpus* spp.). Tall emergent vegetation specifically looks at vegetation commonly used as nesting materials by many marsh bird species. Open water is also an important variable to consider, especially for American coot and pied-billed grebe which feed at least in part by diving.

Elevation of the survey station was also considered. Survey stations ranged in elevation from 781-815 meters. To ensure highly correlated variables were not considered in the same model, a correlation matrix between all pairs of variables was created. Variables with a correlation coefficient greater than 0.7 were not considered in the same model. In these instances, the variable with stronger biological or ecological justification was selected (Nielson, 2016).

Table 1. Detailed descriptions of habitat variables used for abundance estimates.

Variable	Description
Day	Day on which a survey was conducted, measured as number of days since May 1
Visit	Visit on which a survey occurred, treated as a factor with three levels (1-3)
Elevation	Elevation (m) of survey station
Water	Relative percent cover of open water/floating vegetation within 100 m of a survey station
Nuphar	Relative percent cover of *Nuphar* spp. within the "open water/floating vegetation" category, considered for American coot and pied-billed grebes as a proxy for water depth
Emergent	Relative percent cover of all emergent/submergent vegetation within 100 m of a survey station
Woody	Relative percent cover of shrubs and trees within 100 m of a survey station
Tall	Relative percent cover of tall emergent vegetation within the "emergent/submergent vegetation" category, determined by combining percent cover of cattails (*Typha* spp.) and rushes (*Juncus/Scirpus* spp.)

Results and Outcomes

Detections and distribution of focal and primary marsh birds

During the 2018 CWMBMP, all five focal bird species were detected. In terms of focal birds, sora had the highest number of observations (178), compared with American coot at 138, pied-billed grebe with 122, Virginia Rail with 37, and 10 for the American bittern (Figure 5). When compared to the 2017 data, there was an increase in detections of sora, American bittern, and American coot in 2018 (Figure 5). However, fewer pied-billed grebe and Virginia rail were detected in 2018 when compared to 2017. There was 174 point counts conducted at 61 survey stations in 2017, whereas 191 point counts were conducted at 65 survey stations in 2018.

All primary species were detected in 2018 with the exception of the horned grebe (Appendix 1). Red-winged blackbird was the primary species detected most frequently. Thirty-nine of the 68 secondary species were detected in 2018, although not all secondary species area were expected to occur in the study area, e.g. yellow rail (*Coturnicops noveboracensis*), black-crowned night heron (*Nycticorax nycticorax*), and Nelson's sparrow (*Ammodramus nelson*). Of all bird species encountered during surveys, the song sparrow (*Melospiza melodia*) was detected at the highest number of survey stations (58 of 65 stations surveyed), followed by the American Robin (*Turdus migratorius*) that was detected at 56 of 65 stations (Table 2). The song sparrow and American Robin are not focal, primary, or secondary species of the project, but they are 'additional species'. Six bird species considered to be at-risk (through provincial and/or federal listings) were detected: double-crested cormorant (*Phalacrocorax auritus*), bank swallow (*Riparia riparia*), barn swallow (*Hirundo rustica*), eared grebe (*Podiceps nigricollis*), common nighthawk (*Chordeiles minor*), and American bittern (Table 3).

Marsh birds were not distributed equally among the survey stations. The survey station with the highest number of focal birds observed on average was Reflection Lake (within the Town of Golden) with 18.7 focal birds per visit on average, in addition to seven primary birds on average (Appendix 3). Reflection Lake tended to have high numbers of American coot during most point counts, which helps create this high number of focal birds. The highest number of primary birds observed on average was at the Radium Mill Pond 1 survey station (11.3 primary birds on average; four focal birds on average). The survey station with highest overall bird diversity was Fairmont 2, where 42 bird species were observed. Additional survey stations with high numbers of focal birds and/or primary birds included Spilli 1km S, Birchlands, and Old Barns Slough (Appendix 3). These survey stations and others with high diversity, high numbers of focal birds and/or primary birds were observed to contain stands of cattail interspersed with other species of emergent vegetation and open water (Appendix 4). Cattail was often the dominant herbaceous material at the stations that had higher rates of detection for focal and/or primary birds.

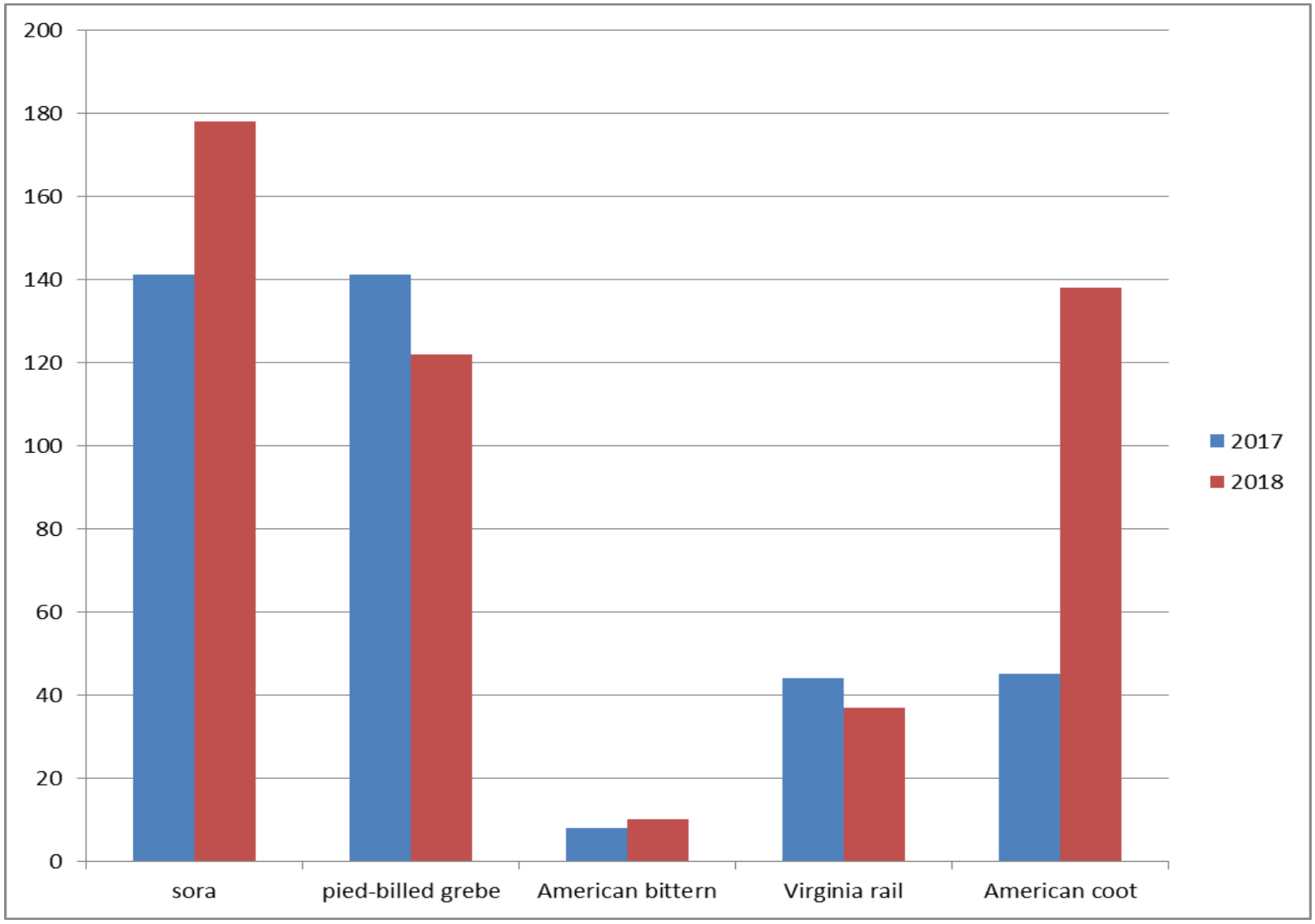

Figure 5. A comparison showing the number of times that focal marsh bird species were observed during repeated marsh bird surveys in 2017 and 2018. Note: there was 174 point counts conducted at 61 survey stations in 2017, whereas 191 point counts were conducted at 65 survey stations in 2018.

Table 2. Listing of the top 10 bird species that were observed at the highest number of survey stations.

Species common name	% of survey stations species was detected	CWMBMP Species Category
Song sparrow	89.2	Additional
American robin	86.2	Additional
Red-winged blackbird	84.6	Primary
Canada goose	80	Secondary
Yellow warbler	80	Secondary
Mallard	78.5	Secondary
Willow flycatcher	78.5	Secondary
Eastern kingbird	78.5	Additional
American crow	76.9	Additional
Sora	73.8	Focal

Table 3. At-risk bird species observed during the 2018 CWMBMP, including the number of survey stations where each species was observed.

At-risk species	No. of stations detected survey (out of possible 65)
Barn swallow	8
American bittern	5
Bank swallow	5
Double-crested cormorant	1
Eared grebe	2
Common nighthawk	1

Abundance estimates from 2016-2018 data

As stated previously, observations which occurred immediately before or after the 15-minute survey window were not included in estimating abundance, but they are included in the summary that illustrates the total observations for focal birds during 2017 and 2018 (Figure 4). All five focal species were detected across study years 2016-2018 (Table 4). Sora was the most frequently detected focal species from 2016-2018, pied-billed grebe was the second, and American bittern was the species detected with the lowest frequency. All primary species, except Brewer's blackbird (*Euphagus cyanocephalus*) and eared grebe, were detected during all study years (Table 5). Red-winged blackbird (*Agelaius phoeniceus*) was the most frequently observed primary species and Brewer's blackbird was the least (Table 5).

Detections of American bittern were quite low overall (Table 4), therefore abundance estimates will not be reported on because numbers were inflated due to the low number of detections. Sora produced the highest abundance estimates with a relatively low uncertainty, as seen by the relatively low coefficient of variation (CV %). We estimated that there were 4,253 sora (95% CI = 3,163-5,719) in the Columbia Wetlands in 2016. We estimated that the abundance of sora was 1,118 (95% CI = 784-1,594) in 2017, and 2,037 individuals (95% CI = 1,540-2,693) in 2018. American coot had the highest abundance estimates during 2016 with 3,019 individuals (95% CI = 1,340-6,800); 501 (95% CI = 158-1,602) American Coot in 2017, and 2,430 (95% CI = 1,128-5,238) in 2018. Model-averaged abundance estimates of American coot had higher uncertainty in all study years, possibly due to their tendency to be observed either in groups of several individuals or not at all (Table 3). Pied-billed grebe abundance estimates in the Columbia Wetlands had relatively low uncertainty across years of survey effort with 1,216 (95% CI = 853-1,732) in 2016; 792 (95% CI = 577-1,086) pied-billed grebes in 2017, and 1,006 (95% CI = 689-1,468) in 2018. We estimated that there were 414 (95% CI = 150-1,143) Virginia rail in 2016; 961 (95% CI = 519-1,781) in 2017, with the highest Virginia rail estimate in 2018 with 1,315 (95% CI = 750-2,307) individuals.

Both Brewer's blackbird (*Euphagus cyanocephalus*) and eared grebe had fewer than ten observations in a single season (Table 5). Therefore their abundance was not estimated due to the low number of observations. For primary bird species, marsh wren (*Cistothorus palustris*) and red-winged blackbird produced the highest abundance estimates with relatively low uncertainty, likely due to a high number of observations (Table 5). We estimated that the abundance of marsh wren was 2,603 (95% CI = 1,777-3,813) individuals in 2016, 3,987 (95% CI = 2,898-5,487) individuals in 2017, and 3,263 individuals in 2018 (95% CI = 2,297-4,636). For red-winged blackbirds, we estimated that the abundance was 3,416 individuals in 2016 (95% CI = 2,548-4,580), 3,141 individuals in 2017 (95% CI = 2,489-3,964), and 3,033 individuals in 2018 (95% CI = 2,384-3,778).

Table 4. Model-averaged abundance estimates and summary table for focal marsh bird species.

Species	Year	Number observed	Survey effort	Avg per visit	Abundance estimate	CV (%)	95% CI	
Sora	2016	151	88	1.72	4253	15	3163	5719
	2017	122	159	0.77	1118	18	784	1594
	2018	161	177	0.91	2037	14	1540	2693
Virginia rail	2016	11	88	0.13	414	48	150	1143
	2017	38	159	0.24	961	32	519	1781
	2018	37	177	0.21	1315	29	750	2307
Pied-billed grebe	2016	108	88	1.23	1216	18	853	1732
	2017	127	159	0.80	792	16	577	1086
	2018	105	177	0.59	1006	19	689	1468
American coot	2016	109	88	1.24	3019	42	1340	6800
	2017	35	159	0.22	501	63	158	1602
	2018	94	177	0.53	2430	40	1128	5238
American bittern	2016	1	88	0.01	N/A	N/A	N/A	N/A
	2017	7	159	0.04	N/A	N/A	N/A	N/A
	2018	10	177	0.06	N/A	N/A	N/A	N/A

Note: The 95% Confidence Interval (CI) is the plausible range for the population parameters given the collected data. CV (%) denotes the Coefficient of Variation, which is the relative standard deviation and is given as a percentage. The number of individuals observed may differ from summaries provided in Figure 5 as only observations within the 15-minute survey window were used to estimate abundance.

Table 5. Model-averaged abundance estimates and summary table for primary marsh bird species.

Species	Year	Number observed	Survey effort	Avg per visit	Abundance estimate	CV (%)	95% CI	
Brewer's blackbird	2016	9	88	0.10	N/A	N/A	N/A	N/A
	2017	0	159	N/A	N/A	N/A	N/A	N/A
	2018	0	177	N/A	N/A	N/A	N/A	N/A
Eared grebe	2016	6	88	0.07	N/A	N/A	N/A	N/A
	2017	0	159	N/A	N/A	N/A	N/A	N/A
	2018	6	177	0.03	N/A	N/A	N/A	N/A
Marsh wren	2016	130	88	1.48	2603	19	1777	3813
	2017	211	159	1.33	3987	16	2898	5487
	2018	175	177	0.99	3263	18	2297	4636
Red-necked grebe	2016	12	88	0.14	221	53	73	665
	2017	11	159	0.07	23	30	12	43
	2018	24	177	0.14	44	20	29	67
Red-winged blackbird	2016	180	88	2.05	3416	15	2548	4580
	2017	306	159	1.92	3141	12	2489	3964
	2018	339	177	1.92	3033	11	2384	3778
Wilsons Snipe	2016	28	88	0.32	104	19	71	152
	2017	25	159	0.16	51	20	34	77
	2018	62	177	0.35	483	23	306	763
Yellow-headed blackbird	2016	54	88	0.61	880	36	436	1776
	2017	58	159	0.36	235	29	134	414
	2018	96	177	0.54	496	27	292	846

Note: The 95% Confidence Interval (CI) is the plausible range for the population parameters given the collected data. CV (%) denotes the Coefficient of Variation, which is the relative standard deviation and is given as a percentage. The number of individuals observed may differ from summaries provided in Figure 5 as only observations within the 15-minute survey window were used to estimate abundance.

Landowner outreach and stakeholder engagement

The CWMBMP continued to develop a growing collaborative with CWS and Ducks Unlimited Canada (DUC). For instance DUC provided guidance in developing a resulting wetland restoration project idea, a project that Goldeneye Ecological Services anticipates implementing in the North Columbia region in 2019. Also, the Canadian Wildlife Service provided funds to a Masters of Ecological Restoration student whom assisted the lead CWMBMP biologist with field surveys, and with analyzing the 2016-2018 CWMBMP dataset to form abundance estimates for marsh birds. Furthermore, in 2018 we conversed or collaborated with regional and national groups, and in particular with the organizations that can have a considerable effect on marsh bird conservation and wetland enhancement, e.g. Ministry of Forests, Lands, Natural Resources Operations and Rural Development (MFLNRORD), Kootenay Conservation Program (KCP), Columbia Wetlands Stewardship Partners, Wildsight, local Rod and Gun Clubs, and the Canadian Intermountain Joint Venture. We also continued dialogue regarding conservation opportunities with groups that have demonstrated experience with landowner outreach in the region, e.g. KCP, Farmland Advantage. The KCP is actively working on a growing collaborative in the Columbia Basin that targets landowner outreach opportunities, synergies and partnerships. Conversations were also had with The Nature Trust of BC regarding recommendations for specific private land parcels for acquisition based upon CWMBMP data that indicates the locations of important marsh bird breeding habitat.

The CWMBMP delivered presentations to five different groups: Columbia Wetlands Stewardship Parnters (25 attendees), Wildsight's Columbia River Field School (in Nicholson, 22 attendees), College of the Rockies Golden campus (18 attendees), Akisqnuk First Nation Chief and Council (8 attendees), and KCP Columbia Valley Conservation Forum (36 attendees). The field season saw seven volunteers participate on marsh bird surveys with the project biologist. Landowner outreach was conducted at two private landowner's properties just north of the Town of Golden, as well as through phone and email communications with an additional landowner (Canfor) whom has private lands in the Columbia Wetlands. Conversations with all of these private landowners were used to educate people about the importance of the wetlands functioning as essential habitat for birds. Outreach was also used to develop potential opportunities for marsh bird habitat restoration or enhancement projects, e.g. wetland restoration on former wood mill site, riparian planting, nesting boxes, removal of railway ties from waterway used by breeding marsh birds.

Discussion

The CWMBMP documents that the Columbia Wetlands ecosystem provides essential and significant habitat for a variety of breeding marsh bird species. Our research data suggests that there is a relatively high abundance of specific focal and primary marsh bird species found in the Columbia Wetlands, particularly pied-billed grebe and sora. The pied-billed grebe abundance estimates have the potential to trigger the 'Important Bird and Biodiversity Area' designation for the Columbia Wetlands. Abundance

estimates show that marsh bird species populations fluctuate from year to year due to changing habitat conditions (as explained in the introduction). The CWMBMP research also suggests that marsh birds are not distributed equally among the landscape, but rather specific habitat parcels in the wetlands appear to be more heavily used than other areas within the wetlands as marsh bird breeding habitat. Reflection Lake is the survey station with the highest number of average focal bird detections. The CWMBMP habitat survey reported that the focal area was composed of 70% herbaceous material (80% of which was cattail), 20% open water and 10% shrubs. A journal article regarding the recolonization of Trumpeter Swans in the Columbia River Wetlands states that:

> "*Reflection Lake is a small and unique habitat patch on the south edge of the town of Golden…[it] is a shallow cattail-bordered 'weedy' lake cut off from the Columbia River flood regime by Highway 95 and the Canadian Pacific Railway and therefore is exceptionally fertile and eutrophic… Reflection Lake's unique ecological character is evident in its regionally rare or local breeding aggregations of redhead (*Aythya americana*), ruddy duck (*Oxyura jamaicensis*), and eared grebe* [at-risk species] *and the number of migrating waterfowl it attracts. It is a rich foraging habitat for swans, as demonstrated by non-breeding pairs that regularly and increasingly feed there despite the surrounding human activity.* (Leighton, 2015).

There has been a noticeable increase in the amount of cattail growing at Reflection Lake. The increase in cattail growth could be due to disruptions in hydrology, nutrient enrichment, and wildfire suppression which all favor growth in cattails (Apfelbaum, 1985). Previous studies have shown that breeding-bird communities inhabiting prairie wetlands in the north have higher densities and diversities in wetlands with a well-interspersed 50:50 vegetative cover:water ratio than in those wetlands with a higher or lower proportion of cover (Weller & Spatcher, 1965; Kaminski & Prince, 1981; Murkin, Kaminski, & Titman, 1982). This 50:50 ratio of interspersed emergent vegetation and open water has been termed the "hemi-marsh" condition and has been used globally for the management of wetlands for waterfowl and other birds (Smith, Haukos, & Prather, 2004). Potential reasons for the greater avian abundance and diversity in hemi-marsh conditions include increased abundance and availability of food and visual isolation or pair-spacing of breeding birds (Smith, Haukos, & Prather, 2004). Working towards achieving the hemi-marsh condition in areas with aggressively growing emergent vegetation due to ecological disruptions, and coupled with documented importance for birds (i.e. Reflection Lake, Radium Mill Pond) should be a conservation priority for the Columbia Wetlands.

An additional conservation parcel that stands out as high value habitat due to the density of American bittern (at-risk species) detections is within the Brisco area, where 10 bitterns were detected at five surveys stations in 2018, all located within 2.5 kilometers of one another. Cooper & Beauchesne (2003) state that:

> *Wetlands that contain breeding American bitterns have habitat attributes that are relatively rare, even when considering only wetlands habitats. Attributes such as sizable and dense areas of emergent vegetation with shallow waters provide breeding habitat for bitterns but also for numerous marsh-nesting species, pond-breeding amphibians, fish and aquatic mammals. In our*

> *opinion, wetlands with breeding American bittern probably provide higher quality critical habitat for the most wildlife species than any other freshwater wetlands habitat type. We suggest that wetlands with breeding American bitterns, which are not already protected as a conservation property, should be considered for [Wildlife Habitat Areas] WHAs.* (Cooper & Beauchesne, 2003)

Of the five survey stations where at-risk bitterns were detected, three are located within the Columbia Wetlands WMA, one is located within the Columbia National Wildlife Area (NWA) (Brisco Unit), and one station is on private land. The main causes of American bittern population decline have been linked to habitat loss, human disturbance, and pesticide/chemical contaminants (Lowther, Poole, Gibbs, Melvin, & Reid, 2009). Since there are far fewer wetlands found now than occurred historically, it is important to target conservation efforts towards habitat parcels with documented importance (e.g. high diversity, breeding habitat for at-risk species) such as Reflection Lake, the wetland habitat surrounding the Brisco area, as well as other wetlands parcels that contain cattail especially where cattail is found in (or close to) the hemi-marsh condition. Ensuring that these habitat areas are conserved and protected will help to ensure that there is a future for marsh birds, as well as for other species that utilize the marsh habitat for their critical life stages.

The CWMBMP has provided ample opportunities for volunteers to participate in educational and science-based marsh bird surveys, and presentations on the project have been given to local stakeholder groups. An additional landowner outreach component was added to the CWMBMP in 2018. This piece focused on educating rural residential landowners in the FWCP North Columbia sub-region (Town of Golden and surrounding areas). It is expected that landowner outreach will lead to future restoration or enhancement projects on private lands in or directly adjacent to, the Columbia Wetlands. However, it is anticipated that ongoing consultations with landowners will be required to facilitate meaningful change. Approximately 32% of the CW is on private land (BC Hydro, 2014), therefore, what happens on private lands has a large impact on ecological services and functions of the wetlands. Future projects on private lands could include: cattail management, cattle exclusion fencing, off-site livestock watering, riparian planting/bioengineering, and reduction in pesticides/fertilizers (Harrison et al., 2010).

Conclusion and Recommendations

The Columbia Wetlands is an important ecosystem that is under increasing pressure from anthropogenic impacts. Marsh birds are so named because they tend to be wetland and riparian habitat specialists. This dependence leaves them especially vulnerable to encroaching development and other threats posed to their populations and the wetlands they depend on. Specific habitat parcels within these wetlands that have been documented as supporting high levels of bird diversity and/or breeding species that are at-risk (e.g. eared grebe, American bittern) and deserve special conservation attention. Abundance does not necessarily capture the entire story of population health and prosperity, but it does provide critical insight for informing how we approach conservation and management. This is particularly true for species that we know little about, such as marsh birds. If the population of a species is relatively low or is thought to have declined, it should trigger initiatives to promote species recovery

and prompt further investigation into what may have brought about the decline. If the population of a species of interest is particularly high in a given area, it may suggest that critical habitat is present and prompt special designation and/or conservation of the area. This study provides a robust baseline data set that will be a strong platform to inform these kinds of decisions. It provides a better understanding of which species are present, how prevalent they are, and where they are in the Columbia Wetlands. These data parameters can all be used to monitor species health moving forward, setting conservation goals and targets, and providing a benchmark for assessing success.

Our recommendations include the following:

- We agree with previous recommendations provided by Lowther, Poole, Gibbs, Melvin & Reid, (2009), in that "wetlands used for breeding by American Bitterns need to be protected from chemical contamination, siltation, eutrophication, and other forms of pollution that harm the birds or their food supplies."
- Completion of the three-year baseline data set in 2019. It is also recommended that repetition of the study following the same protocol be conducted over 5-8 year increments to determine status of population changes using marsh birds as an indicator species measuring impact of environmental factors including climate change.
- Creation of a Wildlife Habitat Area (WHA) in the specific area around Brisco where American bitterns have been observed for three successive years, the area not currently designated as a conservation area (e.g. WMA, NWA). Investigations into the potential of chemical leaching from a nearby commercial plant should also be investigated.
- Advancement of opportunities to conserve marsh bird habitat on private lands including the promotion of the 'Kootenay Conservation Program Stewardship Solutions Online Toolkit' to private landowners. This toolkit provides information outlining practices in the protection of wetland habitat and creation of new wetlands on private properties.
- Increasing levels of non-motorized use can be especially problematic for sensitive waterbird species who may abandon high quality habitat areas for lower quality habitat when disturbed. Widespread public education regarding the impacts associated with human use in wetlands with high bird habitat suitability should be encouraged. Buffer distances from emergent vegetation should be created and observed during critical marsh bird breeding periods (early May to mid-July), and included in public non-motorized recreationists policy/recommendations relating to the Columbia Wetlands use.
- Wetland restoration or enhancement efforts should be pursued in all areas where wetlands have been altered in the Columbia Wetlands. Planting indigenous plant species during restoration should be included, as this can accelerate the recovery of vegetation and discourage invasive plants from coming in (Morgan & Short, 2002; Ruiz-Jaen & Aide, 2005).
- Work with agriculturalists to promote best management practices in wetlands should occur, e.g. cattle exclusion fencing, off-site watering, reduction of pesticide and/or fertilizer use, etc. Partnerships with organizations such as the BC Cattlemen's Association are essential to build

trust with agricultural producers and allow partners to implement direct or stewardship programs in rangeland areas (Harrison, et al., 2010).

- Excessive cattail growth reduces open water needed by birds to forage/move around, and the accumulation of cattail in the wetlands creates anaerobic zones where there is no oxygen or invertebrate productivity. Cattail reduction at Reflection Lake (and other areas of dense cattail growth) to restore the hemi-marsh condition is desirable as unbridled cattail growth threatens important breeding bird habitat, natural plant diversity and habitat heterogeneity. Therefore, test projects on how to control cattail and restore a more natural sediment base are needed. Methodology in the potential containment of cattails including prescribed fires and benthic barriers should be further studied and if feasible, implemented.
- Remove old and deteriorating nest boxes (designed for cavity-nesting waterfowl including wood duck and merganser spp.) as unattended or improperly placed nest boxes will over time become unused and potentially become death traps to hens and ducklings. Install new nesting boxes on lands where habitat is limited, according to Best Practices for installation [e.g. pole/post mount (not tree), predator guard in place] (Bailey & Bonter, 2017; Ducks Unlimited Canada, n.d.).
- Investigate a mosquito control agent [*Bacillus thuringiensis israelensis* (Bti)] currently used in the Columbia Wetlands (CSRD Area A), including its potential negative impact on marsh bird species.
- All privately owned parcels within the Columbia Wetlands should be considered for potential acquisition as conservation land as opportunities arise, ultimately resulting in the expansion of the Columbia Wetlands Wildlife Management Area boundaries.
- Update habitat mapping information for the Columbia Wetlands, so that further priority habitat areas for marsh bird species can be identified, e.g. identify all the areas of the Columbia Wetlands with cattail marsh.

Acknowledgements

The Fish and Wildlife Compensation Program are gratefully acknowledged for their funding support on the Columbia Wetlands Marsh Bird Monitoring Project. Environment and Climate Change Canada Canadian Wildlife Service are recognized for their generous and substantial financial and staff support during 2016-2018 on this project. We would especially like to extend our sincere gratitude to Dr. Mark Drever for his guidance, assistance, and encouragement on this project. The following volunteers assisted the project biologist in the field and are acknowledged for their contributions: Jaylene Harper, Tamika Nagao, Kelly Mason, Bryan Mitchell, Ashleigh Westphal, Verena Shaw, John Jenkins. Verena Shaw is to be graciously thanked for her contributions as a volunteer and field assistant to the project as she conducted many early morning surveys. We also thank Jan Pindroch for graciously creating the study area map for this project as well as Dr. Mark Frobb for his editing contributions. The following individuals are acknowledged for their in-kind support: Ariana McKay and Dr. Bruce Harrison.

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Appendix 1. Bird species and their relevant listings of priority.

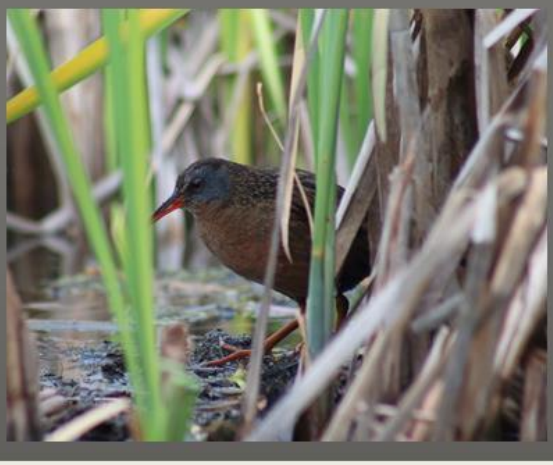
Species (Common Name)	MBMP Focal/Primary/Secondary	FWCP Focal (Y/N)	FWCP Priority (Y/N)	CIJV Priority (Y/N)	Federal listing	Provincial listing	BC List	Detected during 2018 surveys (Y/N)
Sora	Focal		Y			S5	Yellow	Y
Virginia Rail	Focal		Y	Y		S4S5	Yellow	Y
American Bittern	Focal	Y		Y		S3B, SNRN	Blue	Y
American Coot	Focal		Y		Not at Risk	S4S5B	Yellow	Y
Pied-billed Grebe	Focal		Y			S4S5	Yellow	Y
Red-necked Grebe	Primary		Y		Not at Risk	S5?B	Yellow	Y
Horned Grebe	Primary		Y	Y	Special Concern	S4B, SNRN	Yellow	N
Eared Grebe	Primary		Y			S3B, SNRN	Blue	Y
Wilson's Snipe	Primary		Y			S5B	Yellow	Y
Marsh Wren	Primary					S5	Yellow	Y
Red-winged Blackbird	Primary					S5B, S5N	Yellow	Y
Yellow-headed Blackbird	Primary		Y			S4B	Yellow	Y
Rusty Blackbird	Primary				Special Concern	S3S4B	Blue	N
Canada Goose	Secondary					S5	Yellow	Y
Wood Duck	Secondary		Y			S4B, S4N	Yellow	Y
Mallard	Secondary			Y		S5B, S5N	Yellow	Y
Gadwall	Secondary			Y		S5	Yellow	N
Green-winged Teal	Secondary			Y		S5B, S5N	Yellow	Y
American Wigeon	Secondary			Y		S5B, S5N	Yellow	Y
Northern Pintail	Secondary		Y			S4B, S5N	Yellow	N
Northern Shoveler	Secondary					S5B, S5N	Yellow	Y
Blue-winged Teal	Secondary		Y			S4S5B	Yellow	Y
Cinnamon Teal	Secondary		Y	Y		S4B	Yellow	Y
Canvasback	Secondary		Y			S4B, SNRN	Yellow	N
Redhead	Secondary		Y	Y		S4B, S5N	Yellow	Y
Ring-necked Duck	Secondary		Y	Y		S5B, S5N	Yellow	Y
Lesser Scaup	Secondary		Y			S5B, S5N	Yellow	Y
White-winged Scoter	Secondary			Y		S4S5	Yellow	N
Surf Scoter	Secondary					S3B, S4N	Blue	N
Harlequin Duck	Secondary	Y			Special Concern	S4B, S3N	Yellow	N
Barrow's Goldeneye	Secondary		Y	Y		S4S5	Yellow	N
Common Goldeneye	Secondary		Y			S5	Yellow	Y
Bufflehead	Secondary		Y	Y		S5B, SNRN	Yellow	Y
Common Merganser	Secondary					S5	Yellow	Y
Hooded Merganser	Secondary		Y			S5	Yellow	Y
Ruddy Duck	Secondary			Y		S5	Yellow	Y
Common Loon	Secondary	Y		Y	Not at Risk	S5	Yellow	Y
Clark's Grebe	Secondary			Y		S1B	Red	N
Western Grebe	Secondary	Y		Y	Special Concern	S1B, S2N	Red	N
American White	Secondary	Y		Y	Not at Risk	S1B	Red	N

Pelican								
Double-crested Cormorant	Secondary			Y	Not at Risk	S3S4B	Blue	Y
Great Blue Heron	Secondary	Y		Y	Special Concern	S3	Blue	Y
Osprey	Secondary	Y				S5B	Yellow	Y
Northern Harrier	Secondary		Y	Y	Not at Risk	S4B	Yellow	Y
Bald Eagle	Secondary		Y		Not at Risk	S5B, S5N	Yellow	Y
Least Bittern	Secondary				Threatened	SNA	Accidental	N
Green Heron	Secondary					S3S4B	Blue	N
Black-crowned Night Heron	Secondary					S1	Red	N
Yellow Rail	Secondary				Special Concern	S2B	Red	N
Sandhill Crane	Secondary				Not at Risk	S4B	Yellow	Y
Killdeer	Secondary		Y			S4S5B	Yellow	Y
American Avocet	Secondary			Y		S2S3B	Blue	N
Lesser Yellowlegs	Secondary					S4S5B	Yellow	N
Spotted Sandpiper	Secondary					S5B	Yellow	Y
Wilson's Phalarope	Secondary			Y		S4B	Yellow	N
Ring-billed Gull	Secondary					S4?B	Yellow	N
California Gull	Secondary			Y		S2S3B	Blue	N
Herring Gull	Secondary		Y			S5?B	Yellow	N
Glaucous-winged Gull	Secondary					S4	Yellow	N
Black Tern	Secondary		Y	Y	Not at Risk	S4B	Yellow	N
Western Screech-Owl	Secondary			Y	Threatened	S3	Blue	N
Forster's Tern	Secondary					S1B	Red	N
Vaux's Swift	Secondary	Y				S5B	Yellow	N
Belted Kingfisher	Secondary		Y			S4S5	Yellow	Y
Olive-sided Flycatcher	Secondary		Y		Special Concern	S3S4B	Blue	N
Willow Flycatcher	Secondary		Y			S5B	Yellow	Y
Tree Swallow	Secondary		Y			S4S5B	Yellow	Y
Violet-green Swallow	Secondary		Y			S4S5B	Yellow	Y
Bank Swallow	Secondary				Threatened	S4B	Yellow	Y
Northern Rough-winged Swallow	Secondary		Y			S4S5B	Yellow	Y
Cliff Swallow	Secondary		Y			S4S5B	Yellow	Y
Barn Swallow	Secondary		Y		Threatened	S3S4B	Blue	Y
American Dipper	Secondary		Y			S4	Yellow	N
Yellow Warbler	Secondary	Y				S5B	Yellow	Y
MacGillivray's Warbler	Secondary					S5B	Yellow	Y
Wilson's Warbler	Secondary					S5B	Yellow	Y
Northern Waterthrush	Secondary		Y			S5B	Yellow	Y
Common Yellowthroat	Secondary		Y			S5B	Yellow	Y
Le Conte’s Sparrow	Secondary					S4B	Yellow	N
Nelson’s Sparrow	Secondary				Not at Risk	S2B	Red	N
Bullock's Oriole	Secondary					S5B	Yellow	Y

Note: Information on species listings were obtained from the B.C. Conservation Data Centre (2019).

Appendix 2. Advertisement that appeared in both The Golden Star newspaper and the 2018 Wings Over the Rockies festival guide.

Volunteers Wanted on Marsh Bird Monitoring Project



Assist a biologist, experience the Columbia Wetlands, hear & see secretive marsh species. No bird experience necessary, but volunteers should be proficient with use of small watercraft & available 6-8 hrs during an early morning in May or June.

Interested? Contact racheldarvill@gmail.com

Goldeneye Ecological Services gratefully acknowledges the financial support of the Fish and Wildlife Compensation Program, and ECCC Canadian Wildlife Service for their contributions to the Columbia Wetlands Marsh Bird Monitoring Project.

goldeneye ECOLOGICAL SERVICES

FWCP Fish & Wildlife COMPENSATION PROGRAM

Environment and Climate Change Canada | Canadian Wildlife Service

Environnement et Changement climatique Canada | Service canadien de la faune

Appendix 3. Distribution of focal and primary birds across marsh bird survey stations in the Columbia Wetlands.

Station Name	Visit 1		Visit 2		Visit 3		Average # of focal birds	Average # of primary birds	Total # of species detected over all visits*
	# of Focal birds	# of Primary birds	# of Focal birds	# of Primary birds	# of Focal birds	# of Primary birds			
Spilli xing west	2	2	3	2	5	1	3.333	1.667	31
Spilli xing east	4	3	1	5	1	2	2	3.333	22
Stewart's Slough	4	7	2	4	3	2	3	4.333	24
Warner's Slough	0	2	0	3	1	1	0.333	2	30
Brisco xing 2	x	x	1	1	2	3	1.5	2	17
Brisco xing	2	4	4	8	4	11	3.333	7.667	19
Spilli 1km S	23	8	7	9	4	8	11.333	8.333	21
Beaver Lk 1	7	9	1	10	1	9	3	9.333	24
Beaver Lk 2	3	7	2	6	1	4	2	5.667	29
Parson xing West	6	6	2	5	3	3	3.666	4.667	30
Parson xing East	0	2	5	9	6	5	3.666	5.333	30
Imler Rd	1	2	1	2	2	3	1.333	2.333	24
McMurdo South	0	1	1	1	2	3	1	1.667	15
Birchlands	6	5	2	11	5	11	4.333	9	36
9 Mile Slough	2	9	4	6	4	8	3.333	7.667	27
Reflection Lake	41	9	8	5	7	7	18.667*	7	26
Reflection Lake 2	30	4	4	3	2	3	12	3.333	23
Edelweiss 1	5	7	1	5	1	5	2.333	5.667	18
Edelweiss 2	1	7	2	6	0	8	1	7	15
Davidson	3	3	2	6	4	5	3	4.667	32
Beards Creek Rd N	4	5	4	5	4	5	4	5	26
Castledale North	3	5	1	12	8	11	4	8.333	25
Beards Creek Rd S	8	1	2	3	1	2	3.667	2	25
Castledale Rest Area	1	3	1	6	4	5	2	4.667	26
McKeeman's	3	0	1	0	2	0	2	0	27

Salsbury Rd N	4	2	3	2	3	9	3.333	4.333	27
Old Barns Slough	2	3	7	3	5	4	4.667	3.333	22
Luxor Station 3	7	1	0	0	x	x	3.5	0.5	31
Radium Mill Pond 1	5	15	3	9	4	10	4	11.333**	26
Radium Mill Pond 2	4	11	1	8	4	9	3	9.333	29
Wilmer 1	1	2	0	4	1	9	0.667	5	26
Wilmer 2	0	0	0	1	3	6	1	2.333	36
Wilmer 3	0	3	1	5	3	7	1.333	5	26
Bittern Lake	1	1	0	0	1	1	0.667	0.667	22
Mitten Lake North	0	2	0	1	0	1	0	1.333	17
Wilbur Lake	0	1	0	0	0	3	0	1.333	17
Loon Lake	0	0	0	0	0	0	0	0	16
Brisco-Spilli 1	3	5	2	2	5	5	3.333	4	33
Brisco-Spilli 2	3	8	2	6	5	9	3.333	7.667	39
Brisco-Spilli 3	0	3	1	2	4	6	1.666	3.667	34
Brisco-Spilli 4	0	3	1	0	2	5	1	2.667	25
Brisco-Spilli 5	0	1	0	0	1	2	0.333	1	32
Harrogate-Castledale 1	2	2	4	0	3	1	3	1	30
Harrogate-Castledale 2	0	0	0	0	0	1	0	0.333	23
Harrogate-Castledale 3	2	2	0	2	1	1	1	1.667	36
Harrogate-Castledale 4	0	2	1	1	0	1	0.333	1.333	27
Harrogate-Castledale 5	0	1	1	1	1	0	0.667	0.667	28
Harrogate-Castledale 6	0	1	0	0	0	1	0	0.667	24
Parson - Beaver Lk 1	2	3	1	2	0	0	1	1.667	41
Parson - Beaver Lk 2	1	7	0	7	2	5	1	6.333	34
Parson - Beaver Lk 3	2	5	1	7	4	4	2.333	5.333	31
Parson - Beaver Lk 4	0	4	0	1	2	2	0.667	2.333	30
Parson - Beaver Lk 5	0	1	0	1	0	0	0	0.667	22
North Parson 1	3	6	0	4	x	x	1.5	5	25
North Parson 2	0	1	0	0	0	1	0	0.667	29
North Parson 3	0	3	0	3	2	6	0.667	4	32
North Parson 4	0	1	0	0	0	1	0	0.667	27

North Parson 5	0	1	0	3	2	2	0.667	2	35
North Parson 7	4	3	1	7	6	5	3.667	5	34
Athalmer	6	3	1	2	5	5	3.667	3.333	25
Lillian Lake	x	x	1	0	3	0	2	0	19
SE Lake Windemere	3	6	2	4	1	4	2	4.667	29
Fairmont	10	14	0	5	0	5	3.333	8	38
Fairmont 2	5	4	2	5	2	6	3	5	42
Columbia Lk N	4	0	2	3	0	1	2	1	28

Note: * denotes the survey station with the highest average number of focal birds. ** denotes the survey station with the highest average number of primary birds.

Appendix 4. Survey station locations and habitat descriptions.

Station Name	lat	long	elev	% herb	% water	% mud	% trees	% shrubs	Lemna	Nuphar	Potamogeton	Nyphaea	Cattails	Reeds	Grass/Sedge	Rushes	Equisetum
Spilli xing west	50.89764	116.3892	796	20				5	50				95				
Spilli xing east	50.90453	116.3698	794	20	50	10		20		25			90				
Stewart's Slough	50.89091	116.3834	797	60	30		5	5					60				30
Warner's Slough	50.84223	116.3251	794	10	80			10					30		65		
Brisco xing 2	50.82823	116.2892	794	10	50		20	20		2					90		
Brisco xing	50.82977	116.2835	796	45	40	10		5					40			60	
Spilli 1km S	50.90178	116.3622	792	30	60			10		95			100				
Beaver Lk 1	51.13290	116.7483	788	90			5	5					60			40	
Beaver Lk 2	51.12802	116.7468	791	45	35		5	15		3			40				55
Parson xing West	51.06161	116.6499	791	45	25	5	5	20					15	25	50		
Parson xing East	51.07185	116.6415	788	85	10			5					60			25	
Imler Rd	51.09775	116.6883	793	30	25	5	5	35					20		60		
McMurdo South	51.13787	116.7559	786	70	5		5	20					45		25		
Birchlands	51.15865	116.8136	785	80	5			15					15		85		
9 Mile Slough	51.19847	116.8773	788	90	10					5	20		60			30	
Reflection Lake	51.28328	116.9414	784	70	20			10				2	80				
Reflection Lake 2	51.28545	116.9499	784	40	40		5	15					80		10		10
Edelweiss 1	51.32010	116.9776	784	65	18		2	15			30		50		20	10	10
Edelweiss 2	51.32313	116.9853	786	55	5	15	15	10					50			30	10
Val Davidson	51.06456	116.6596	788	60	20		15	5			5		35		25	40	
Beards Creek Rd N	51.04951	116.59720	801	20	80					75			15				
Castledale North	51.04049	116.5773	793	35	60			5		90			10			80	
Beards Creek Rd S	51.03299	116.5572	792	15	75		5	5		65			90				
Castledale Rest Area	51.02691	116.5363	798	5	90			5		85			90				
McKeeman's	51.01866	116.517	791	10	80		5	5		5					2	95	
Salsbury Rd N	50.99863	116.4742	794	80	10		5	5					20			80	
Old Barns Slough	50.96389	116.4215	806	75	5			20					25		50		2
Luxor Station 3	50.77008	116.2158	794														
Radium Mill Pond 1	50.62204	116.094	801	15	80			5		65			90		10		
Radium Mill Pond 2	50.62389	116.105	797	45	30	10	5	10		70			85			15	
Wilmer 1	50.55660	116.0682	800	70	25			5		35			35			75	
Wilmer 2	50.55863	116.0607	811	10	80		10			15	1				70		
Wilmer 3	50.56212	116.0617	814	65	15			20					85				15
Bittern Lake	50.97910	116.5997	1005	10	65		15	10		0.5					50	50	
Mitten Lake North	50.97710	116.5803	1015	75			10	25		2			20		45	35	
Wilbur Lake	51.00959	116.6771	1295	5	95					1					98		
Loon Lake	51.05515	116.8025	1235	5	75	5		15							95		
Brisco-Spilli 1	50.83211	116.2937	791	55	30			15					70		30		
Brisco-Spilli 2	50.83319	116.3009	793	50	30			20					20		70		10
Brisco-Spilli 3	50.83746	116.307	794	40	53	2		5							30	60	10
Brisco-Spilli 4	50.84179	116.314	794	50	30			20					10		15		75

Brisco-Spilli 5	50.85126	116.3249	793	30	55			15		45					55		35
Harrogate-Castledale 1	50.96533	116.4421	786	35	50		5	15		45			30		30		40
Harrogate-Castledale 2	50.96528	116.4534	794	15	65		10	10							90		
Harrogate-Castledale 3	50.97353	116.4644	791	70		1		29							100		
Harrogate-Castledale 4	50.98212	116.4741	792	70	10		10	10							100		
Harrogate-Castledale 5	50.98709	116.4759	792	30	50			20							100		
Harrogate-Castledale 6	50.99172	116.4806	791	10	65		10	15							100		
Parson - Beaver Lk 1	51.06898	116.6627	789	2	78			20							85		10
Parson - Beaver Lk 2	51.07295	116.6689	787	65	20			15					30		20	40	10
Parson - Beaver Lk 3	51.08289	116.6759	789	15	70			15					85		10		
Parson - Beaver Lk 4	51.08228	116.6887	790	25	55			20					70		15		10
Parson - Beaver Lk 5	51.08756	116.7001	785	35	30		5	30								60	35
North Parson 1*	51.13258	116.7615	781	10	75			15								85	
North Parson 2	51.13098	116.7777	790	35	30			35					60		15		20
North Parson 3	51.13446	116.781	786	10	80			10					30		60		10
North Parson 4	51.14123	116.7984	788	35	45		5	15					10		30		50
North Parson 5	51.14575	116.805	795	25	50	5		20					55		40		
North Parson 7	51.15272	116.8129	790														
Athalmer	50.51605	116.0221	800	98				2					65		30	2	3
Lillian Lake	50.50316	116.098	939	5	93			2					100				
SE Lake Windemere	50.41394	115.9268	802	15	80			5		8			95		5		
Fairmont	50.34489	115.8725	806	75	15			10							85		
Fairmont 2	50.34953	115.8708	802	35	35		5	25							70	20	5
Columbia Lk N	50.30677	115.8526	815	85	5		5	5					95				