Environment and Climate Change Canada

Canada Nature Fund: Community-Nominated Priority Places for Species at Risk

Kootenay Connect: 7CW Columbia Wetlands:

Columbia Wetlands Floodplain Wetland Hydrology and the Role of Beaver Dams

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Environment and Climate Change Canada / Environnement et Changement climatique Canada

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1. Executive Summary

CWSP has been monitoring the water levels, vegetation, waterbirds and water quality of the Columbia Wetlands in Columbia Valley, East Kootenay, BC. Little knowledge was available on the hydrology and ecology of the Columbia Wetlands prior to the Kootenay Connect project. We found that individual floodplain wetlands can be categorised hydrologically based on their connection to the flood pulse of the Columbia River as Most, Partially, and Least Connected. Those wetlands that are Most Connected to the Columbia River (CR) have channels (gaps) through the natural levees which allow input of flood waters when the CR rises during the spring melt in June and drain out again when the CR levels drop in autumn. Least Connected wetlands are only filled with water when the water goes overtop the natural levees (and beaver dams). The water is retained over the winter into the following spring. Partially Connected wetlands have gaps in the natural levees which allow some floodwaters to enter but are partially blocked by beaver dams or debris.

We found that the interaction between the flood pulse of the Columbia River, the natural levees which bound the wetlands, and beaver dams explains 60% of the hydrological variation between these wetland groups. 46% of sampled wetlands in the Partially and Least Connected groups had beaver dams controlling water levels. Across the whole ~18,000 ha Columbia Wetlands floodplain, 74% of wetlands are in the Most Connected group, while only 26% are Partially or Least Connected wetlands. This means that most of the wetlands drain out over the winter when the water levels of the Columbia River fall. Beaver dams are important for retaining water in the wetlands over winter and early spring before the spring melt in May and June.

By monitoring water levels for six years, we have water level data for three high water years (2020, 2021, and 2022) and three low water years (2023, 2024, and 2025). There are cumulative impacts of successive low water years on wetlands, with successive years having increasingly reduced peak and low water levels. Partially Connected wetlands appear to be the most at risk wetland group; in high water years, the average low water is approximately 1 m, but in low water years the average low water is approximately 0.5 m. The differences between these years emphasises the importance of multiple years of data for large complex systems like the Columbia Wetlands. We also used isotope analysis to determine relative contributions of river water, groundwater, and precipitation to different wetlands throughout the year, finding that groundwater contributes most in the spring and fall while in the summer river water dominates.

We have also studied ecological differences between wetland groups. Both emergent and submerged vegetation differs between wetland groups, and migratory bird use of the wetlands also differs. Partially and Least Connected wetlands support a higher species diversity of migratory waterbirds in the spring, as they retain water over the winter and so provide open water habitat in early spring when these bird species are migrating through the Columbia Wetlands. Partially and Least Connected wetlands provide habitat for species that need deeper, stable water, while Most Connected wetlands provide habitat for birds that prefer shallow water and muddy edges. All wetland groups support similar numbers of individual birds in the spring, and in the autumn, there are no significant differences in either numbers of birds or numbers of species in the different wetland groups. In spring, we observed between 4,800 and 7,500 individual birds across all wetland sites, and in fall between 8,600 and 14,200 individual birds across all wetland sites. Across four years of bird surveys, we have observed more than 62,000 individual birds.

In 2022, we began to look at using Beaver Dam Analogues (BDAs) as a restoration technique to restore selected wetlands, where natural beaver dams had blown out or been removed by humans, in order to increase the amount of Partially Connected wetlands within the floodplain. However, this has proved difficult to implement due to permitting requirements by the provincial government.

2. Introduction

The Columbia Wetlands, stretching from Columbia Lake in the south to just north of Golden in the north, are floodplain wetlands along the only undammed portion of the Columbia River, and are one of the longest contiguous wetlands in North America (Zimmerman, 2004). As floodplain wetlands in an undammed system, they are maintained by the natural flood pulse of water flowing over the natural river levees and advancing and retreating across the valley, a process that has major effects on all aspects of the wetlands (MacDonald Hydrology Consultants Ltd., 2021; Makaske *et al.,* 2009). The flood pulse – the overbank flow of water across the landscape during a high water period (Junk *et al.*, 1989) – is an essential driver that determines floodplain connectivity and transport of both organic and inorganic material, from organisms to sediment, but other sources of water such as local rainfall or rising groundwater also contribute to the hydrological and ecological dynamics of floodplain wetlands (Amoros and Bornette, 2002; Junk *et al.,* 1989; Tockner *et al.*, 2000). Like all floodplain wetlands, the Columbia Wetlands are a complex system (Figure 1), with many processes operating at different temporal and spatial scales.

Figure 1: Aerial photo of a section of the Columbia Wetlands just upstream of Spillimacheen in May 2022.

The Columbia Wetlands are habitat for a large diversity of organisms and are particularly important for migratory waterbirds (Figure 2). They comprise an important part of the Pacific Flyway; one of North America's four major migratory routes (Environment and Climate Change Canada, 2018). The Columbia Wetlands Waterbird Survey, which covered approximately 39% of the total Columbia Wetlands area, found that in 2019, across three dates, 41,095 birds of 90 different species were present in the wetlands, and across the five years of the survey 163 bird species were documented, with a maximum single day count of 20,822 individuals on 15th October 2016 (Darvill, 2020).

Figure 2: Three bird species found in the Columbia Wetlands. Top left: Trumpeter Swan, Bottom left: Ruddy duck, Right: Bald Eagle.

Despite their importance as an undammed floodplain wetland and their high biodiversity the Columbia Wetlands and this reach of the upper Columbia River have not been well studied, and while they are faced by many threats, including climate change, these impacts are also not well understood. The Columbia Wetlands are particularly sensitive to climate change for several reasons. Annual temperatures in the Columbia Wetlands have already increased by 1˚C and further increases of 2 ˚C to 4 ˚C are projected. Changes to precipitation amounts, timing, and form are also predicted by models, with less snow and more rain falling in the valley (Utzig, 2021). As the Columbia Wetlands are dependent on the natural flood pulse, which is primarily driven by snowmelt and rainfall depending on season (Makaske *et al.,* 2009), the decreasing snowpack of the Canadian Rockies and changes in precipitation are a direct and urgent threat to the hydrology of the Columbia River and its floodplain wetlands. There is less water in the Columbia Wetlands today than historically (Hopkinson *et al.*, 2020), and projections indicate that there will be increasingly less water in the future (Utzig, 2021).

Beavers may provide some natural mitigation of the effects of climate change on the Columbia Wetlands by increasing wetland resilience and complexity, and specifically by increasing open water area (Hood and Bayley, 2008). Beavers have profound effects on wetlands and are often termed ecosystem engineers for the extensive changes they provoke, providing both direct ecosystem services and economic benefits to people (Thompson *et al.*, 2021). They shape the wetland systems that they occur in by changing the hydrology and associated processes such as sediment transport and increasing habitat complexity and biodiversity across all taxonomic groups, from invertebrates to mammals (Larsen *et al.*, 2021; Nummi and Holopainen, 2020). However, the role of beavers within the Columbia Wetlands was also not well understood.

3. The Floodplain Wetlands and the Role of Beaver Dams

CWSP has been working in the Columbia Wetlands for the full seven years of this project, and each year has allowed us to build on the work of previous years and better our understanding of the wetlands. In 2019, CWSP began study of the Columbia Wetlands by getting LiDAR taken of the whole wetland area, approximately 22,000 ha, and drone imagery taken of 14,444 hectares. This drone imagery was used to generate emergent vegetation mapping for the wetlands.

In 2020, CWSP began to study 38 wetlands between Invermere and Parson (Figure 3). These 38 sites are 23.32 km^2 in total, or just over 10% of the total area of the Columbia Wetlands, with individual wetlands ranging from 0.04 km^2 to 3.27 km^2 in size. Every year, CWSP has collected a variety of data from these wetlands. We use water level loggers to collect water level data between May and October and measure water quality several times during that same period and have collected sediment samples from all the wetlands. We have surveyed levee gaps and beaver dams across all the wetlands. In 20 of the wetlands, we have conducted more intense monitoring, including migratory waterbird surveys in spring and fall from 2021 to 2025 (with plans to continue through 2026) and submerged aquatic vegetation (SAV) surveys in August 2021 and 2023. A more detailed description of our fieldwork methods and a full list of site coordinates can be found in Appendix 1 and 2.

Since 2020, in collaboration with Dr. Ryan MacDonald and MacHydro Consultants Ltd., CWSP has also been using modeling techniques to study the impacts of climate change currently and in the future on these wetlands. In collaboration with the University of Lethbridge, we have used remote sensing techniques to determine and predict large-scale changes of vegetation and open water within the Columbia Wetlands in response to climate change.

In 2022, we began to look at using Beaver Dam Analogues as a restoration technique to restore selected wetlands, where natural beaver dams had blown out or been removed by humans.

We have continued all this work in the years since, and collecting data over multiple years allows us to build a better understanding of this complex system, as it means we can compare between years with different conditions, look at the differences in wetlands pre- and post- restoration, and perhaps even begin to predict and document the impacts of climate change.

Collecting data over multiple years allows us to build a better understanding of this complex system, as it means we can compare between years with different conditions, look at the differences in wetlands pre- and post- restoration, and perhaps even begin to predict and document the impacts of climate change. We recognize that we have examined short term processes (5-10 years) that contribute to the dynamic nature of floodplain wetlands but have not looked at the watershed and reach scale processes that control the entire floodplain dynamics such as the routing of water through different channels, sediment erosion, aggradation and transport.

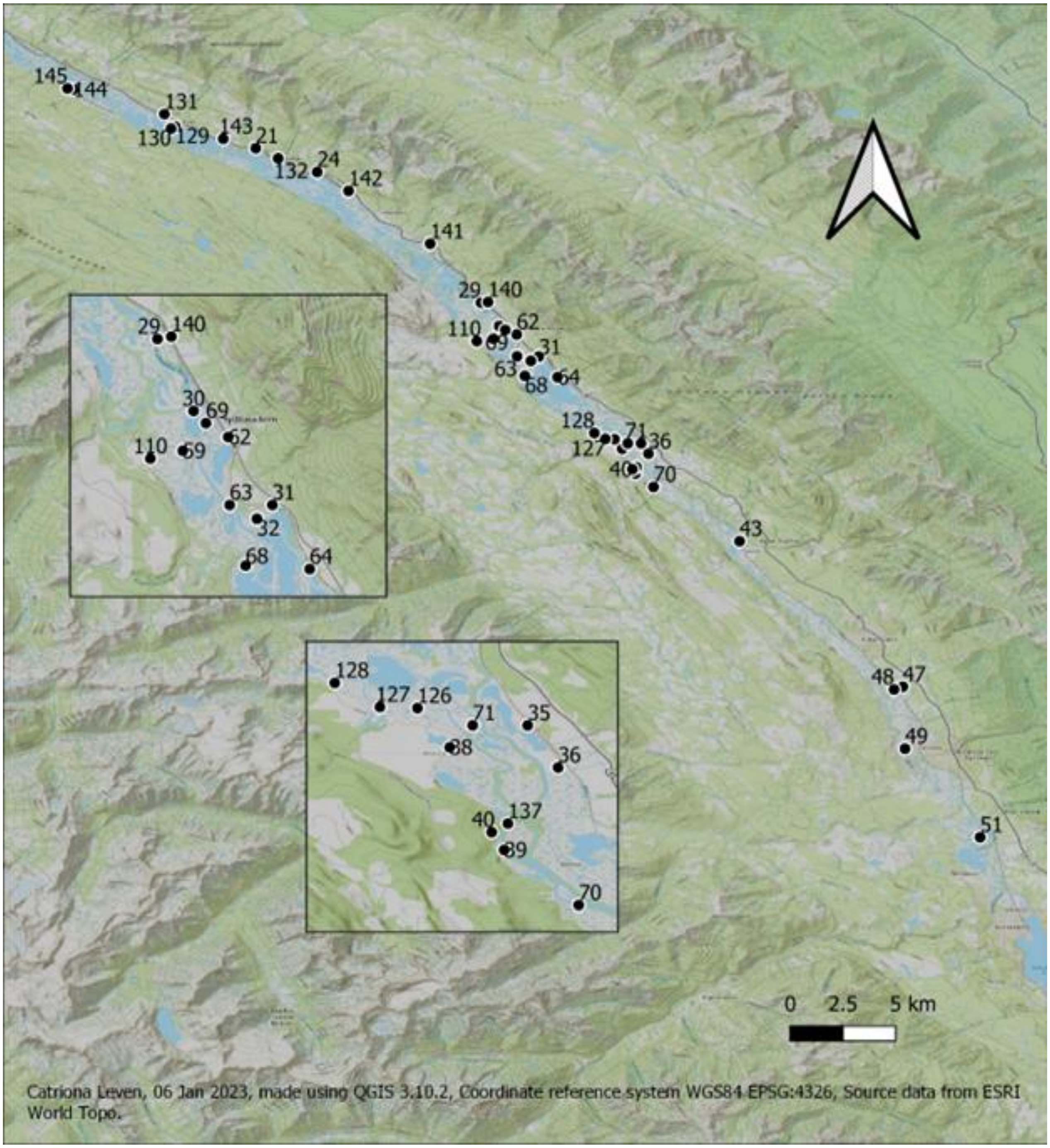

Figure 3: Map of study sites in the Columbia Wetlands.

3.1 Hydrologic classification of the Columbia Wetlands and the role of beaver dams

Based on our work since 2020, we have determined the differences in hydrology between different wetlands, and classified our study wetlands into groups defined by their connectivity to the Columbia River: 1) Most Connected, 2) Partially Connected, and 3) Least Connected (more details can be found in Leven, 2024, Leven *et al.*, 2024, and Leven *et al.*, 2025). By understanding differences in hydrology between wetlands, we can better understand the functioning of the Columbia Wetlands as a whole and the various driving factors within the wetland complex. We can also look at the ecological differences resulting from the different wetland hydrology, such as the different habitats provided for bird species.

The different wetland groups can be recognised on the landscape (Figure 4). Most Connected wetlands have shallow or no water in the spring and fall, while Least and Partially Connected wetlands retain deeper water all year round, and have less fluctuation in water depths throughout the year. The differences between these wetlands are most visible in the spring and fall, as in the summer in high water years the Columbia River flood pulse will flood into all of these wetland groups. These hydrological differences are also visible in the vegetation growing within these wetlands: Least Connected wetlands support Cattail and Bulrush communities, and submerged aquatic vegetation such as Water Lilies, while Most Connected wetlands support Sedge and Shrub communities, and often have areas of open mudflat in the spring and fall.

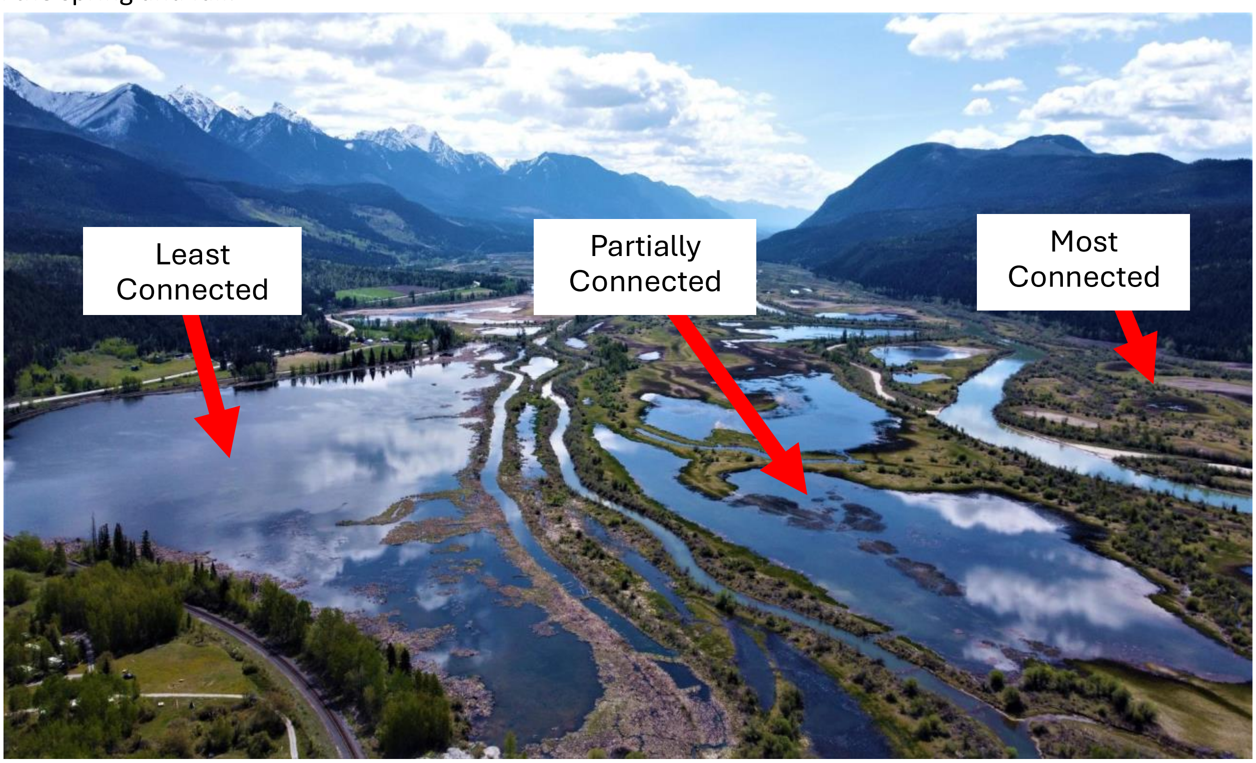

Figure 4: Aerial photo of the Columbia Wetlands showing the three different groups, taken in May before the natural flood pulse and summer high water. Note the open water present in the Least and Partially Connected wetlands, while the Most Connected wetland does not have open water.

We have determined that the interaction between the river flood-pulse, natural levee gaps, and beaver dams determines approximately 60% of the hydrological differences between these wetland groups (Leven, 2024). Many of the individual wetlands within the Columbia Wetlands complex have one or more gaps in the natural levees that enclose them which allow for greater connectivity to the Columbia River, as water is able to flow through these gaps before the river floods enough to overtop the levees. The Columbia River only floods high enough to overtop the levees in approximately 65% of years (Rodrigues *et al.*, 2024), and these levee gaps are the only way that water can enter the wetlands in years when the river does not flood over the natural levees. Beavers build their dams both within wetlands and within these levee gaps, and in doing so change how water enters and leaves wetlands. In contrast to most studies of beaver impacts on riverine systems where the water flows are unidirectional, in the floodplain system, water flows in from an adjacent river (here the Columbia River) over the beaver dam into the wetland and then out again. In the spring, as the flood pulse rises, water flows over the beaver dams from the Columbia River into the wetlands; once the flood pulse has receded, the water flows out of the wetlands (either over, through, or under the dams, if they are present) into the Columbia River. Thus, the beaver dams operate on water flow in both directions.

We have determined three scenarios for how water enters individual wetlands within the Columbia River floodplains (Figure 5). In Scenario 1 in Figure 5, the natural levee surrounding a wetland, built by the gradual deposition of sediment over many years, is unbroken, without any gaps in it. Thus, the river must rise more than 2.5 metres from its pre-flood pulse depth so it can overtop the levee and enter the wetland. However, while it is harder for water to enter the wetland, it is also harder for water to leave the wetland, and so these wetlands will hold more water as the flood pulse recedes. In scenario 2, the natural levees have a gap in them, and so the water has to rise much less and will be able to easily flow into and out of this wetland. In scenario 3, beavers have built a dam across the gap in the levee and so have created an intermediate scenario, with water not having to rise as high to enter the wetland, but also being retained within the wetland by the beaver dam as the flood pulse recedes.

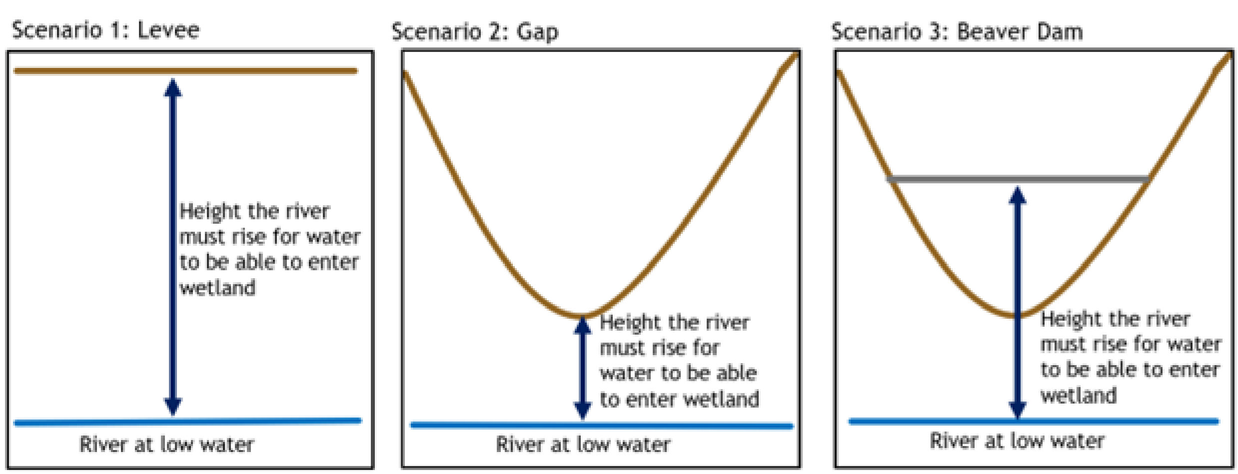

Figure 5: Schematic of the role of levee gaps and beaver dams in influencing the flood pulse entering wetlands.

These scenarios align well with our different wetland groups, as can be seen in Figure 6. The Most Connected wetlands almost all have open levee gaps, with water easily able to flow into and out of these wetlands. The majority of Partially Connected Wetlands either have levee gaps dammed by beaver dams or no levee gaps; the differences in levee height and beaver dam size, condition, and location mean this wetland category is the most variable. The Least Connected wetlands all have no levee gaps or the levee gaps are dammed by beaver dams; these wetlands tend to have more or larger beaver dams separating them from the Columbia River.

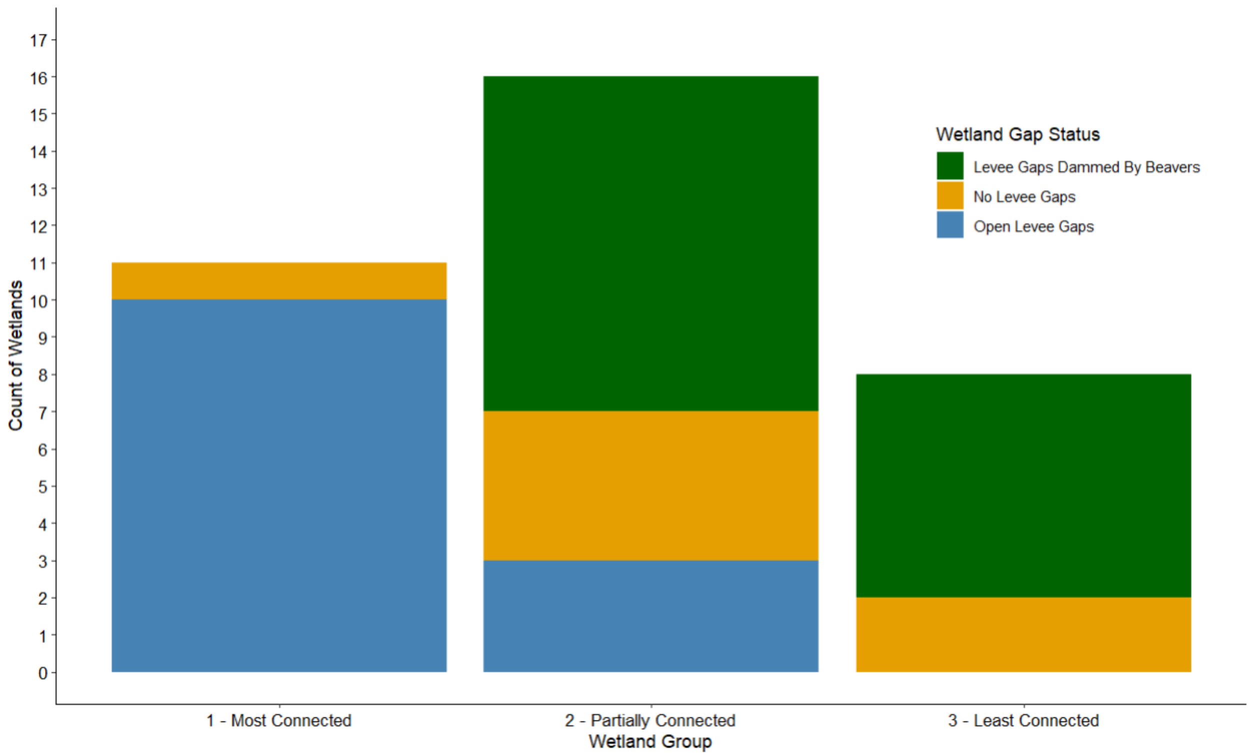

Figure 6: Number of wetlands with open levee gaps (blue), no levee gaps (yellow), or levee gaps dammed by beavers (green) in each of the three wetland groups.

These different wetlands can occur next to each other within the floodplain, which emphasises the role of beaver dams and the differences between these wetlands. As can be seen in Figure 9, the Least Connected wetland has areas of deep open water and Cattail, while the Most Connected wetland has shallow open water and Sedge communities.

Figure 7: Least and Most Connected wetlands next to each other.

We initially identified 76 levee gaps and 205 beaver dams using imagery as having potential impacts on our 38 study wetlands, and then with fieldwork determined that 45 levee gaps and 28 beaver dams were directly impacting our study wetlands. The longest dam measured was 150 m long, the tallest 1.83 m high, and the widest 6.5 m wide. Some wetlands had 5% of their entire perimeter area dammed by beaver dams.

Figure 8: Beaver dam found within the Columbia Wetlands. The Columbia River is behind the photographer.

While within our study sites, we have more Partially and Least Connected wetlands than Most Connected wetlands, across the whole Columbia Wetlands Most Connected wetlands are the most common type of wetland. 74% of the Columbia Wetlands are Most Connected wetlands, which means they are fully connected to the flows of the Columbia River and have a large increase in water depths during the summer months, and are very shallow or completely dry during the rest of the year.

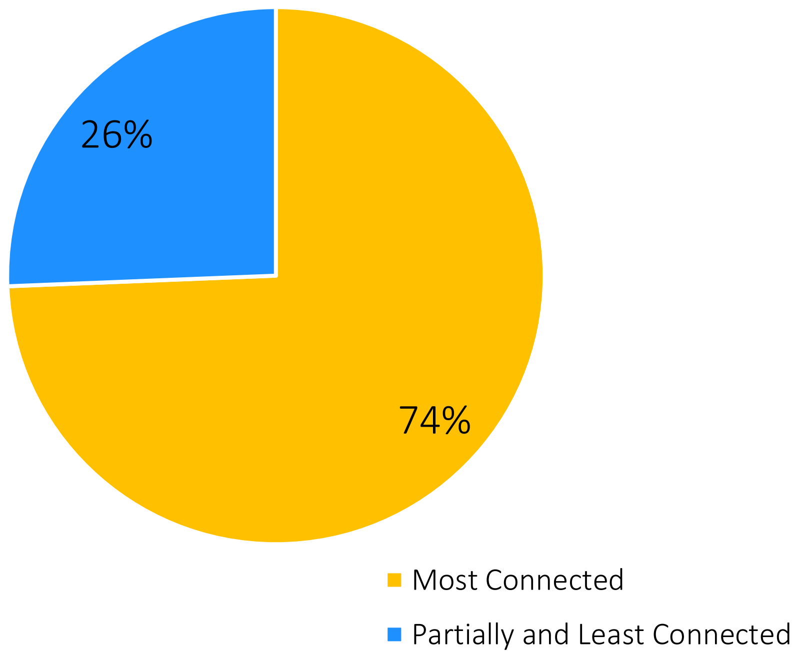

Figure 9: Percent of Columbia Wetlands that are Most or Partially/Least Connected.

All of these wetland types contribute to the high biodiversity of the Columbia Wetlands; the different habitat conditions within the different wetlands provide habitat for different organisms across all taxonomic groups. Maintaining all of these wetland types within the Columbia Floodplains is crucial to retaining the high biodiversity and functionality of the Columbia Wetlands.

3.2 Wetland water levels since 2020

As we have monitored water depths in our 38 study sites since 2020, we have been able to compare these depths across six years, from 2020 to 2025. 2020, 2021, and 2022 were all high-water years, while 2023, 2024, and 2025 were low water years, which can clearly be seen both in the overall response of all the wetlands in each year and within each wetland group (Figure 10). In 2020, 2021, and 2022, the mean highest depth of wetlands was more than 2.5m, while in 2023 it was approximately 2.25m, in 2024 approximately 2m, and in 2025 approximately 1.75 m, indicating the reduced flood pulse in these low water years. This emphasises the cumulative effect of dry years on all the wetlands within the Columbia Wetlands, no matter which wetland group they are in, with successive dry years having greater impacts than isolated dry years.

The Least Connected wetlands show the least response to differences in high and low water years; even in 2025 where a flood pulse can barely be observed in these wetlands (Figure 10, green line on the 2025 panel), the average water level remains at approximately 1.5 m throughout the year, which is the level that these wetlands return to even in high water years. Least Connected wetlands usually have substantial water inflow from other sources, either streams or groundwater springs, and so the river is contributing less to water levels in these wetlands. Thus, they are less negatively impacted by years of low water. However, the inflow of river water is important for other reasons in these wetlands, even if water levels are less directly impacted than in the other wetland groups. The river inflow provides a flushing effect, providing low-impact disturbance that prevents plant species such as Cattails dominating the wetland. It also brings an influx of nutrients and microscopic life that enriches the wetland.

The Most and Partially Connected wetlands, however, show strong differences between high and low water years. The Most Connected wetlands begin and end the year at low water levels, however the smaller flood pulse results in far lower water levels in these wetlands in the summer. This is the peak growing time for many species, and lower water levels result in different conditions.

The Partially Connected wetlands may be the ones most impacted by low water years. These wetlands retain some water over the winter, often due to beaver dams, but do not have the strong alternate water sources that the Least Connected wetlands tend to have. Therefore the lack of a flood pulse results in not only lower water levels during peak flow in the summer, but lower water levels at the beginning and end of the year, because there is less water flowing into these wetlands that the beaver dams and natural levees can retain; in 2020, 2021, and 2022 (high water years) the average water depth in these wetlands in April and October was approximately 1 m, while in 2023, 2024, and 2025 (low water years) the average water depth in these wetlands in April and October was approximately 0.5 m. This drop in water levels is particularly substantial when considered across the whole area of these wetlands, as this resulted in less open water and flooded area across all these wetlands.

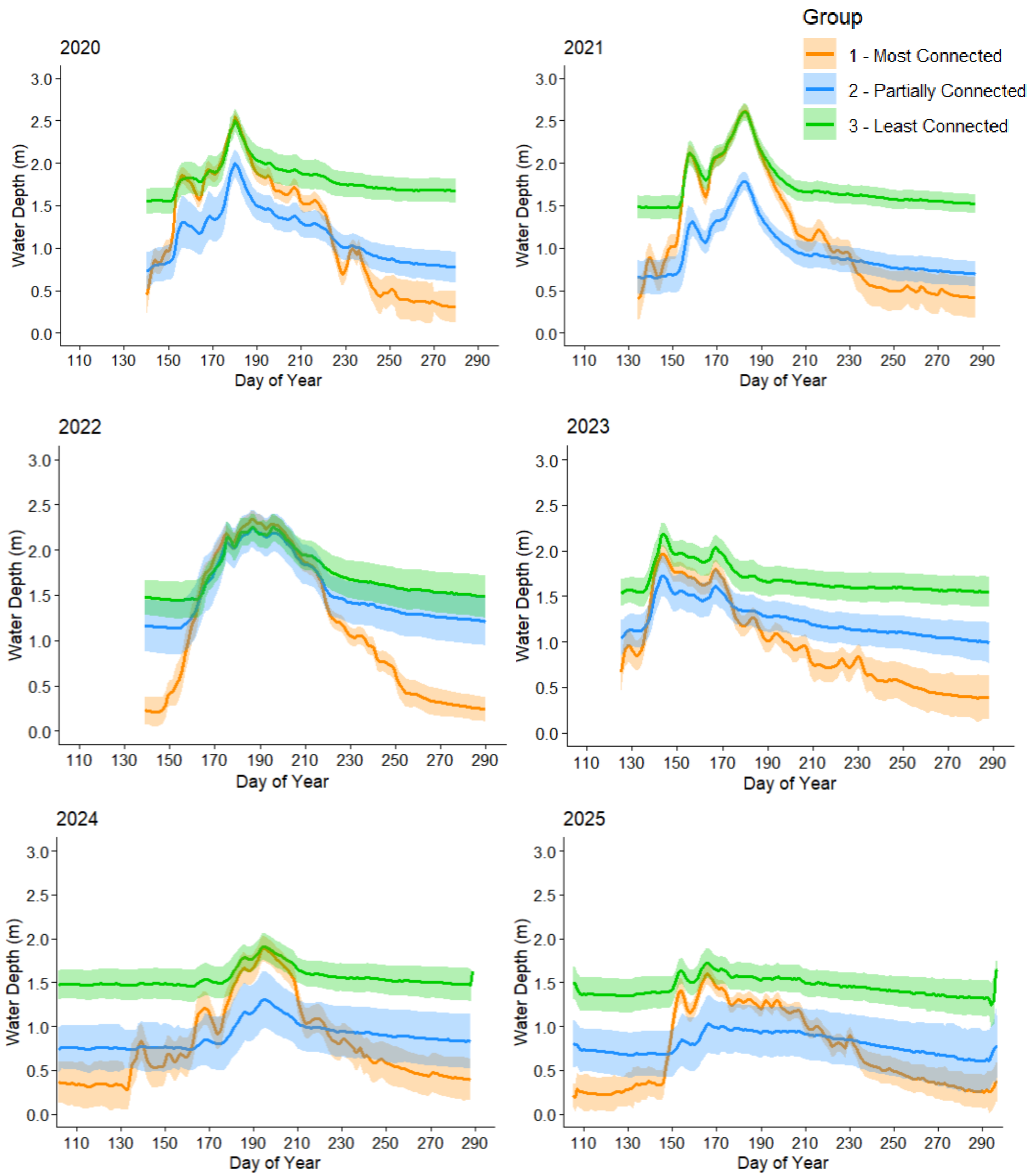

Figure 10: Mean water depth in all wetland groups across all six studied years. Shaded areas represent standard error for each wetland group.

This work also shows the benefits and need for longer-term research and monitoring projects. The amount of variability in water levels shown in the six years demonstrates that studying only one, or even three, of these years would not have provided an adequate picture of how the system is functioning because the Columbia River and associated wetlands are so variable. Only by collecting multiple years of data can we begin to understand how these systems are functioning, and how these systems are changing and may continue to change over time, particularly in the face of climate change. By being able to compare both high and low water years we can make better predictions about changes in response to climate change.

3.3 Differences in birds between wetland groups

We are also interested in the ecological differences between wetland groups that arise due to the differing hydrology. We wanted to understand how these groups differed in terms of water quality, plants, and birds in order to better understand the rich diversity of the Columbia Wetlands complex. We also want to better understand how to protect and conserve this diversity, and understanding how different wetland groups contributes to that will allow us to make better informed conservation decisions. We are particularly interested in migratory bird use of the Columbia Wetlands.

General Bird Observations

We have recorded 164 species in and around our study wetlands either during dedicated waterbird counts or incidentally while working in the wetlands (full list of species in Appendix 3) between 2021 and 2025. 14 of these are Species at Risk (Appendix 5). The use of wetlands by these species varies widely, from ducks using open water to rest and feed, swallows and other insect eating birds catching food over the wetlands, small passerines such as warblers nesting in wetland vegetation, and shorebirds using exposed mud and short vegetation around the edges of wetlands to feed.

Spring and Fall Migratory Waterbird Counts

We have recorded 106 species during our spring (April) and fall (October) waterbird counts between 2023 and 2025. 57 of these species are waterbirds or birds of prey, and it is with these groups of birds that we have done further analysis of our data, as these are the groups our surveys are targeting. Across all our years of surveying and all wetlands, we have counted more than 62,000 individual waterbirds and raptors. In spring, we observed between 4,800 and 7,500 individual birds across all wetland sites, and in fall between 8,600 and 14,200 individual birds across all wetland sites. Fall 2025 had the greatest number of birds, with 14,200 individual birds counted in total, and 5,154 individual waterbirds being counted on a single wetland across five counts; on three different counts this wetland had more than 800 waterbirds on a single day, predominantly American Wigeon. These repeated high counts in Fall 2025, coupled with warm temperatures throughout the count period, suggest that birds were gathering and not continuing to migrate south, as the warm temperatures resulted in plenty of open water and food being available throughout October and into November.

Across all years and seasons, there are no significant differences in either number of individual birds or number of species using the different wetland groups (Figure 11). This is due to the large variation in birds and species using individual wetlands within each group, and due to the differences in wetland use between spring and fall. The Most Connected wetlands have the most variation within them, partly because conditions within them vary the most depending on water levels within the Columbia River, and so will support very different numbers of birds even within one season depending on daily conditions.

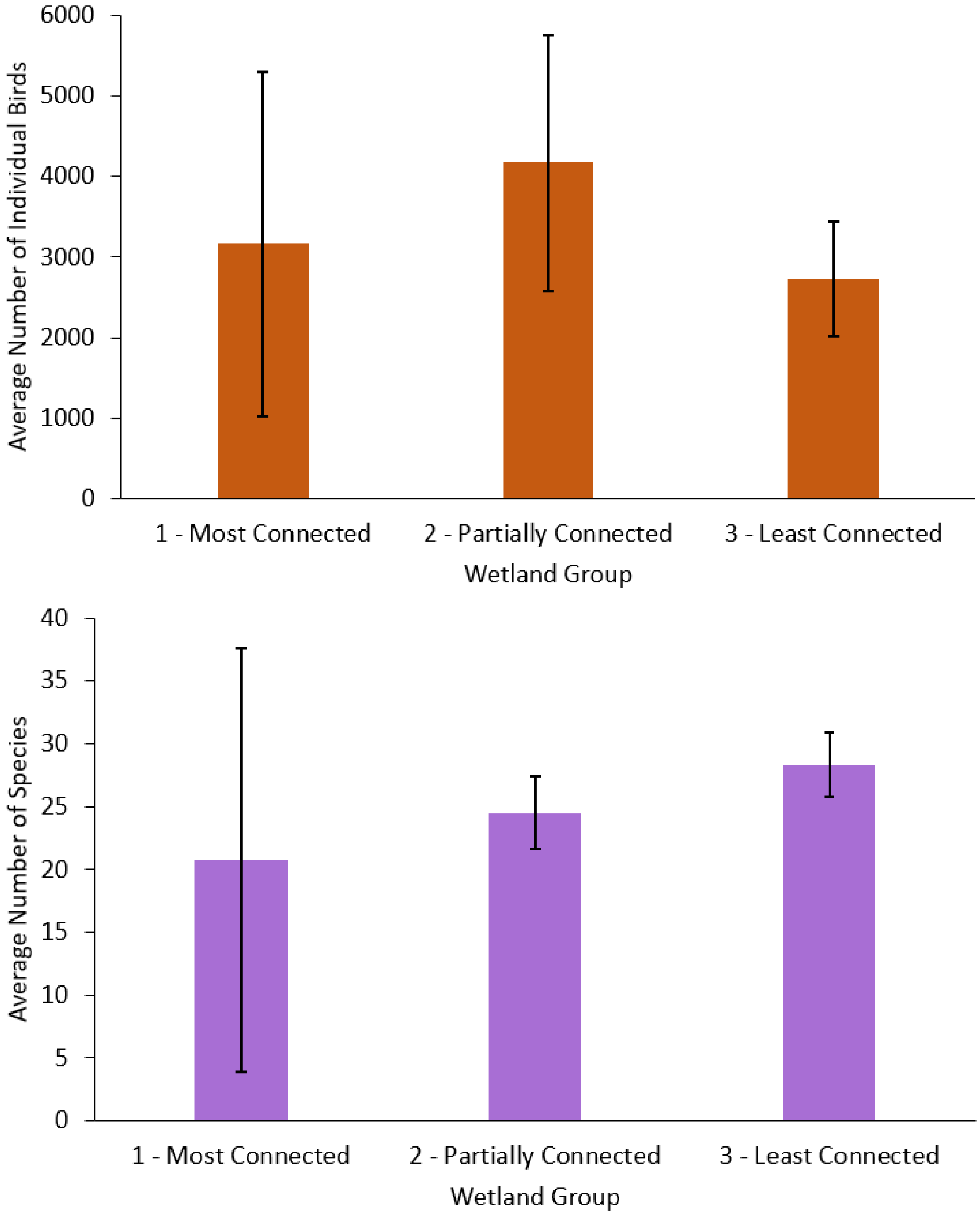

Figure 11: Number of individual birds (above) and number of species (below) using the different wetland groups across all years and seasons; error bars are standard error.

As can be seen from Figure 12, across the three years of our surveys, there are fewer individual birds observed in the spring across both the Most and Partially Connected wetlands, but more birds observed in the spring in the Least Connected wetlands. This highlights the importance of the Least Connected wetlands in retaining water in the spring for migratory waterbirds. In the spring, in both 2024 and 2025 Partially and Least Connected wetlands had a significantly higher average number of individual birds observed, while in 2023 all three wetland groups had almost the same average number of individual birds observed in them. This is likely because 2023 had a very early flood pulse (as can be seen in Figure 10 above), so water levels were high in the Most Connected wetlands during spring migration. However, in 2024 and 2025, the river did not rise so early, and so the water retained over the winter by the Partially and Least Connected wetlands was more important, providing open water habitat during migration before the river flood pulse could fill the Most Connected wetlands.

In all three years there are more birds observed in the fall than the spring. This is partly because there simply are more birds in the fall, as many young birds hatched in summer and migrated, whereas by the following spring and birds are returning north, many of these birds will have died during migration or on the wintering grounds. In the fall birds also move much more slowly. While in the spring there is a strong imperative for birds to get to the breeding grounds early to increase chances of successful breeding, in the fall, birds will be much more responsive to local weather conditions, and may linger in the same area for weeks before moving south. The very high bird numbers observed in fall 2025, may well be due to it being a very warm fall, and so many birds stayed on the wetlands to the end of the survey period, whereas in previous years birds moved through faster.

However, as can be seen by the large standard error bars in this figure, there is so much variation between individual wetlands in each group in average number of individual birds, particularly in the fall, that more definitive conclusions cannot be drawn. Within wetland group variation is very large, depending on both individual day and individual wetland. For example, in fall 2025, within the Partially Connected group of wetlands (seven wetlands), the total number of individual birds observed across all survey dates ranged from 90 to 5154. suggesting that birds are also choosing wetlands based on factors other than water availability. Some of the wetlands where the most birds are found in the fall, are also wetlands with abundant submerged aquatic vegetation, suggesting that this may be a factor in bird choice of wetland. It is likely that human disturbance also plays a role, as we have observed birds leaving wetlands when disturbed by vehicles or trains.

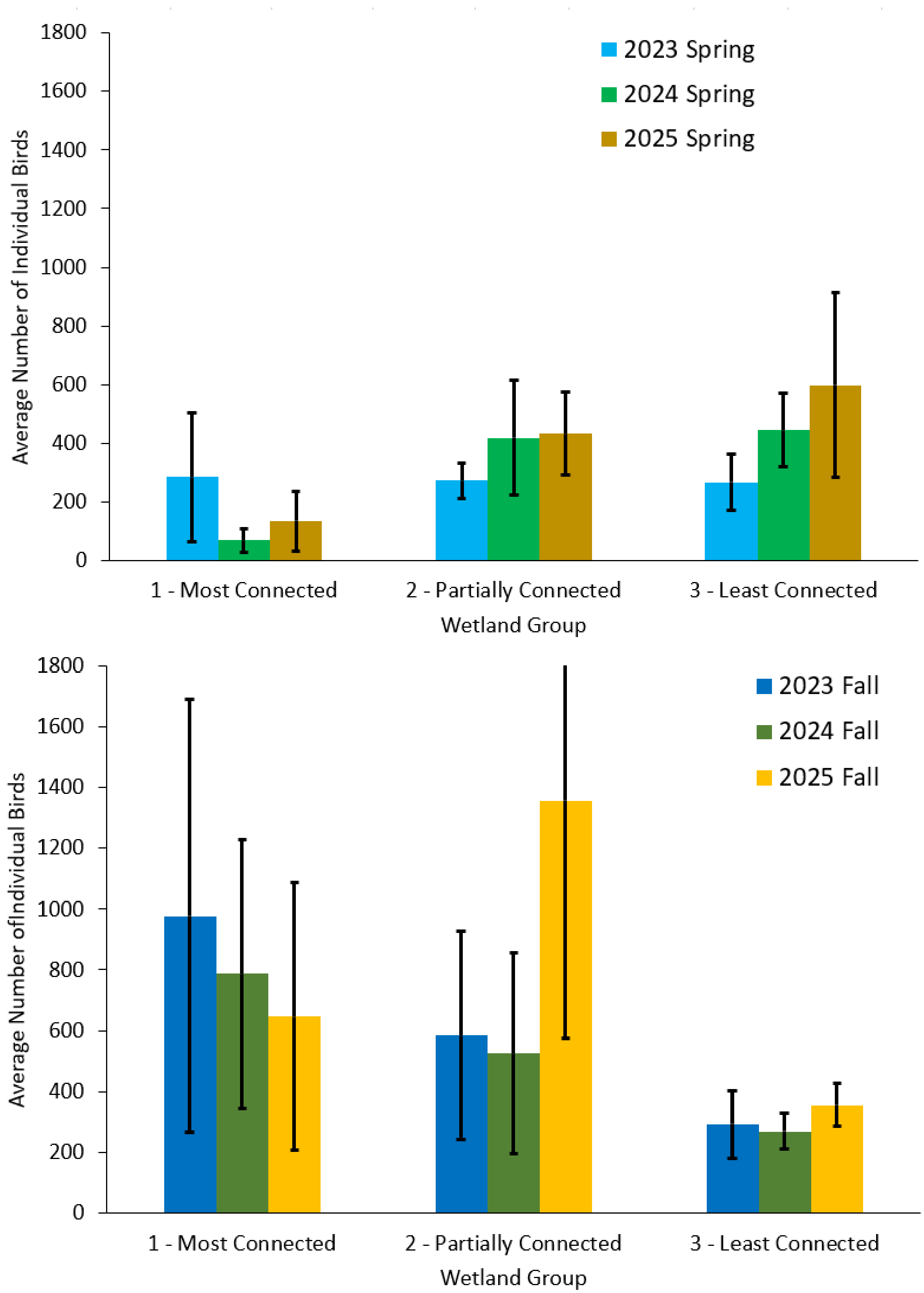

Figure 12: Average number of individual birds observed in the different wetland groups in 2023, 2024, and 2025, in spring (above) and fall (below). Error bars are standard error.

While the large range in numbers of individual birds within each wetland group varies greatly, there are more striking differences in the average of number of species using each wetland group in the spring. As can be seen in Figure 13, there are significantly more bird species in Partially and Least Connected wetlands in all three years. This is because in the spring, many of the Most Connected wetlands do not provide the right habitat for species of migratory waterbirds that like deeper water, such as Bufflehead, Mergansers, Goldeneye, and all the Grebe species, so these are only observed in the Partially and Least Connected wetlands. This demonstrates how important these types of wetlands are in the spring, as without them there would be reduced area of habitat for these species. In the fall, however, there are no differences in the numbers of species observed across the different wetland groups, due to higher water levels in the fall in the Most Connected wetlands: this reduces the difference between the wetland groups. In the fall, species may also be selecting habitat differently, as discussed above, because they are remaining in the area for longer and because there is more water on the landscape, so the water depth and area within the Partially and Least Connected wetlands is a less scarce habitat.

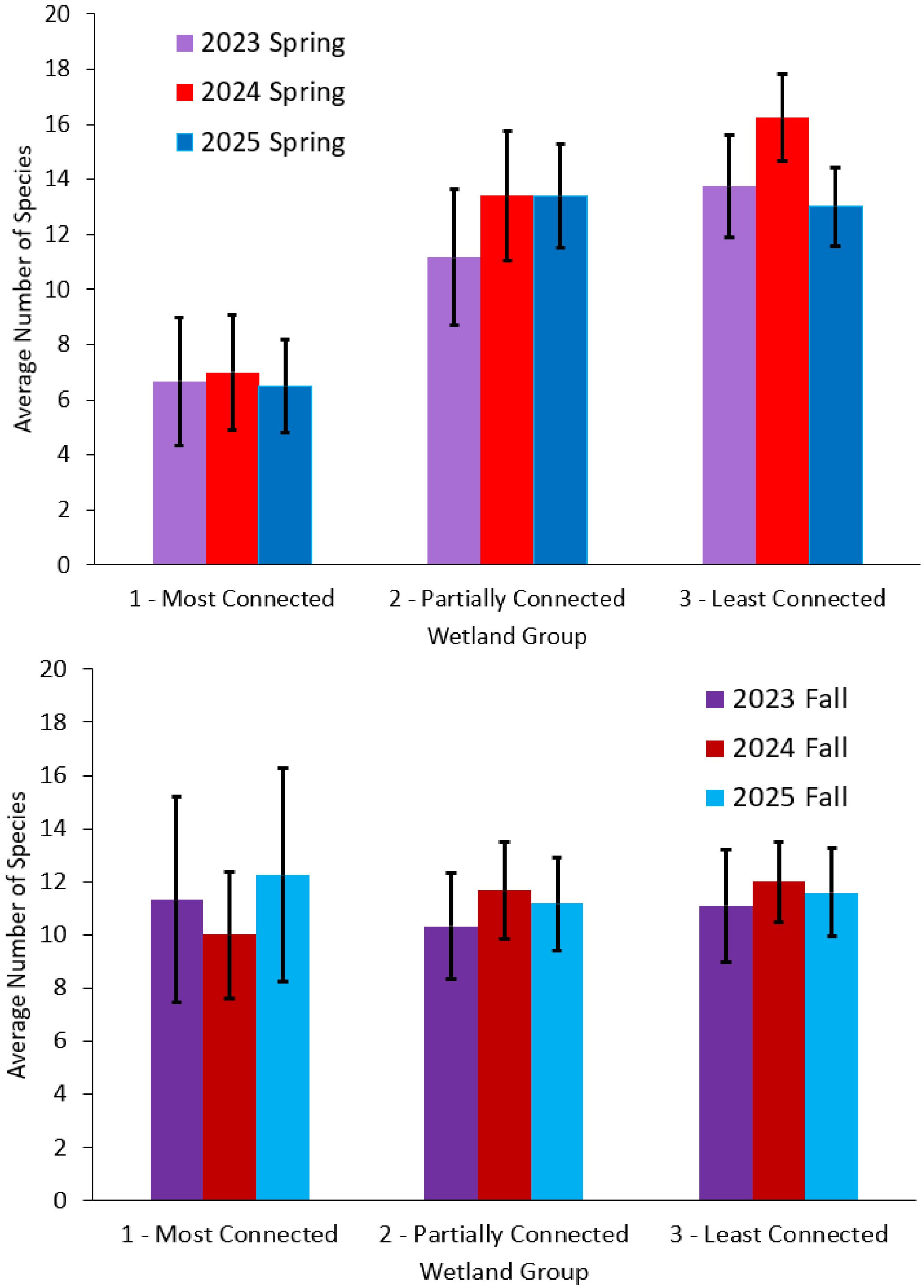

Figure 13: Average number of bird species observed in the different wetland groups in 2023, 2024, and 2025, in spring (above) and fall (below). Error bars are standard error.

3.3 Water Quality Monitoring

Water quality monitoring was conducted within the floodplain wetlands in April, June, and October using a calibrated YSI probe. Across all sampling periods, we measured temperature (°C), pressure, dissolved oxygen (% and mg/L), specific conductance (µS), conductivity (S/m), pH, and turbidity (NTU). Monitoring in June aligned with peak freshet, during which the river showed high water levels, the warmest temperatures, and high turbidity levels, comparative to the April and October monitoring periods. Full results are provided in Appendix 6.

4. Restoration Using Beaver Dam Analogues: Future Plans

Beaver Dam Analogues (BDAs) are human-built structures that mimic or reinforce natural beaver dams. They try to replicate the features of natural beaver dams, and so are semi-porous, temporary features, built with natural local materials including sediment, wooden posts, and branches. They are constructed either in a location where there used to be a beaver dam (these are locations CWSP targeted in our work) or locations where it would be likely that beavers would build a dam. BDA's aim to mimic the effects of natural beaver dams as well, by retaining water within a system, and thus hopefully resulting in positive impacts to habitat complexity, biodiversity, and the other myriad impacts of beaver dams discussed above. We hope that BDAs will, much like natural beaver dams, increase the amount of water retained in wetlands, particularly over the winter, so that open water habitat is available for migratory waterbirds when they migrate through the Columbia Valley before the Columbia River flood pulse begins. As discussed above, Partially and Least Connected wetlands are both less common on the landscape and support a greater diversity of migratory bird species during the spring, and so increasing this type of wetland on the landscape using BDAs provides valuable habitat and supports biodiversity. In addition, some of the human degradation to the wetlands has been to break levees and destroy beaver dams. Targeting these wetlands for restoration would help mitigate human damage to the wetlands.

The valley bottom wetlands in the Columbia Valley can store large volumes of water within their basins. While this is great from a conservation and restoration perspective, this complicates the ability to acquire permits for BDAs in this system. For restoration projects that store over 10,000 m^3 (which is easily accomplished in these wetlands) a water license is required but can not be held by an NGO on provincial crown land. In addition, storage volumes exceeding this amount require review by a Professional Engineer and consultation with the provincial Dam Safety team. CWSP has explored multiple options for building BDAs within selected valley bottom restoration sites including having a First Nations government act as a tenure holder (was not accepted by the province) or only installing wooden posts to encourage beavers to construct dams in certain levee gaps. Unfortunately, promoting beavers to store over 10,000 m^3 also requires a water license and thus wasn't an option despite this being a regular impoundment volume by beavers within this system. CWSP provided examples of large water volumes held by beavers from some of our 'partially connected' and 'least connected' study sites; however, this did not sway the province's decision. Some examples of large impoundments include CWSP Site #21 which has one large beaver dam and multiple places where beavers have increased the height of the natural levees which store 54,591 m^3 of water, and CWSP Site #129 which has two beaver dams that store 39,925 m^3 of water (volume calculations were performed using LiDAR data).

After multiple meetings with the province, CWSP may have found a potential solution to construct a BDA at one of the valley bottom restoration sites (CWSP Site #145). This permit application is still in review, but we are hopeful that we will be able to construct the BDA in Spring 2026. The maximum height of a BDA to store less than 10,000 m^3 at this site is 0.25 m tall. An overflow pipe will be installed, and maintained, at the 0.25 m height in the BDA to ensure no additional volume could be stored if beavers were to add to the height of this structure (Figure 14). The BDA will be built to a total height of 1 m to secure the overflow pipe, but it will only be capable of increasing the water height by 0.25 m as additional water will flow through the pipe. At this height, the BDA will store an additional 8854 m^3 in this wetland, spread out over 54,080 m^2. Depending on the success of this project, CWSP may pursue applying this method to other valley bottom wetlands.

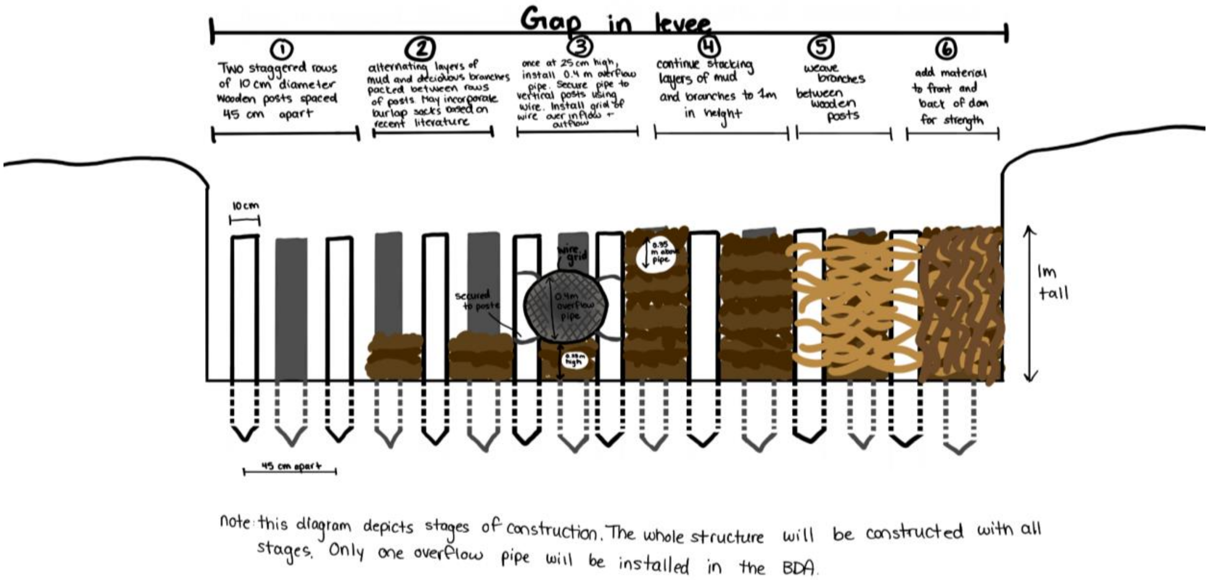

Figure 14: Schematic drawing of BDA construction with inserted overflow pipe. This design has been made specifically for CWSP Site #145. Note this is not an engineered design or drawing.

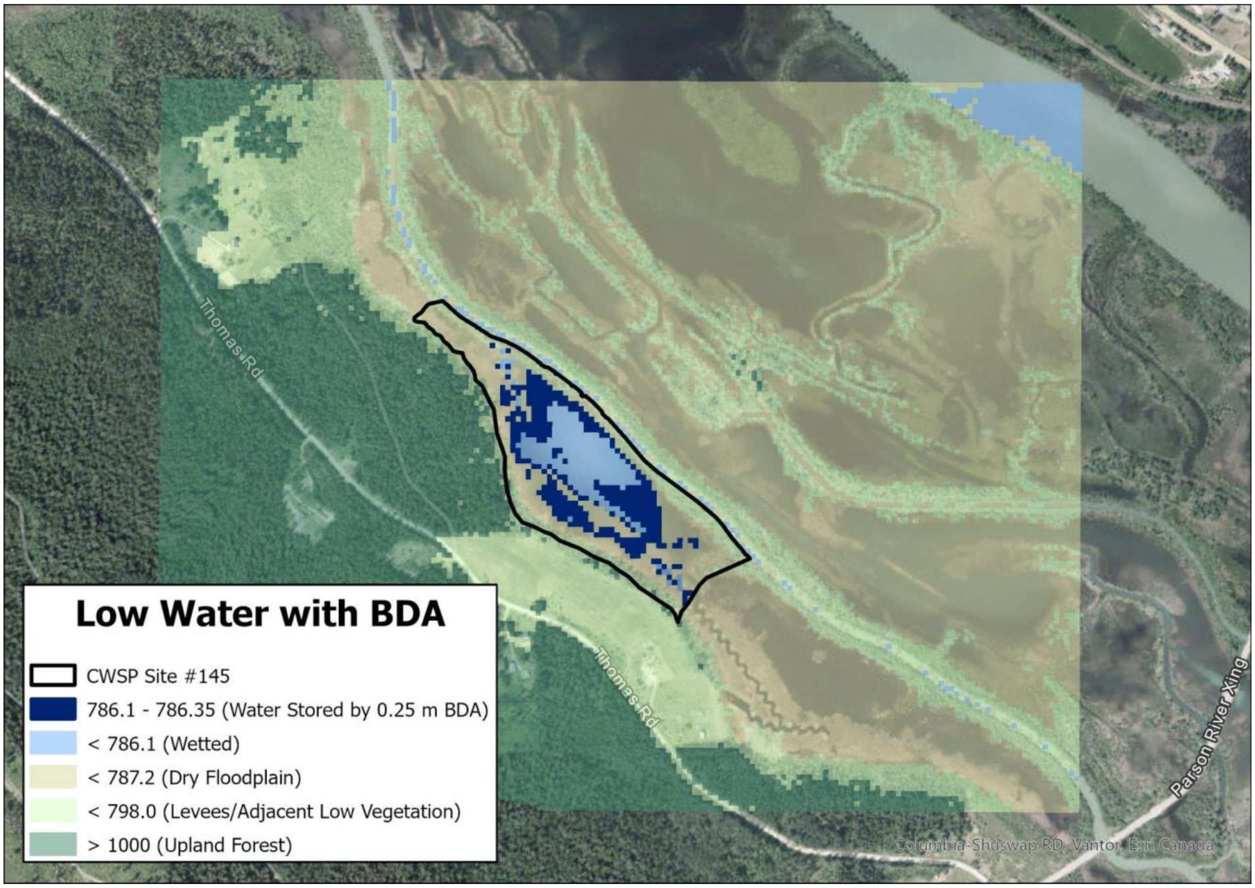

Figure 15: Elevation mapping completed using LiDAR data (accessed from the BC Government Website). The elevation of wetted extent during low water (786.1 m) was determined based on drone imagery of CWSP Site #145 at low water and the height of the Columbia River. The water elevation of 786.35 reflects the water added by increasing storage by a 25 cm tall BDA.

5. Communications

As well as conducting research and restoring wetlands, we also endeavour to communicate with both the general public and with other conservation and research organisations in various ways. In the last year we have given several presentations to different groups of people (Table 1).

Table 1: List of presentations given by CWSP personnel between April 2025 and March 2026.

Date	Presenter(s)	Occasion	Presentation Title
May 2025	Catriona Leven	Wings Over The Rockies Festival	Ecology and waterbirds of the Columbia Wetlands
May 2025	Catriona Leven	Radium Hot Springs Library Public Talk	Birding 101: An Introduction to Birding
June 2025	Suzanne Bayley	CWSP AGM	1) Overview of CWSP project activities and funders and 2) Columbia wetlands

			stewardship partners strategic framework update
June 2025	Catriona Leven	CWSP AGM	Wetland Restoration with Beaver Dams in Wetlands on the Columbia Valley Benchlands
July 2025	Catriona Leven	Wildsight Youth Columbia River Field School	Columbia Wetlands hydrology and ecology and the role of beaver dams
October 2025	Catriona Leven	What's the Future of Grasslands and Rangelands in the East Kootenay? Conference hosted by Columbia Mountains Institute of Applied Ecology (CMIAE)	Grassland Wetlands on the Western Bench of the Columbia Valley
November 2025	Catriona Leven	Radium Hot Springs Library Public Talk	Wetlands in Winter
February 2026	Suzanne Bayley	CMIAE and Kootenay Conservation program Winter Webinar series	Wetland Conservation and Restoration in a Warming Climate: The Role of Beaver Dams

We are also collaborating with and sharing information with organisations such as Living Lakes Canada, the British Columbia Wildlife Federation, and Ducks Unlimited Canada. Specifically, we are advising Ducks Unlimited and BC Parks on their restoration of wetlands at Burgess James Gadsden Provincial Park and have attended site visits and meetings to discuss restoration options and provide data and advice from our work. We also work closely with and share accommodation with the Columbia Headwaters Aquatic Restoration Secwépemc Strategy team. Dr. Suzanne Bayley was also a part of the Columbia Valley Recreational Planning Initiative in Steamboat and Forester Recreational Planning Initiatives, which were community initiatives to better manage recreation in Columbia Valley.

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7 Appendices

7.1 Appendix 1: List of sites

Including easting and northing, 2020, 2021, 2022, and modal group, and whether bird surveys were conducted at each site.

Site	Easting	Northing	2020 Wetland Group	2021 Wetland Group	2022 Wetland Group	Modal Group	Bird Surveys
21	532535	5652873	4 - Least Connected	3 - Least Connected	3 - Partially Connected - Smaller Gaps	Least Connected	Yes
24	535422	5651111	1 - Most Connected	1 - Most Connected	1 - Most Connected	1 - Most Connected	Yes
29	543167	5641399	ND	1 - Most Connected	1 - Most Connected	1 - Most Connected	No
30	544030	5639666	1 - Most Connected	1 - Most Connected	1 - Most Connected	1 - Most Connected	Yes
31	545913	5637403	2 - Partially Connected - Bigger Gaps	3 - Least Connected	2 - Partially Connected - Bigger Gaps	Partially Connected	Yes
32	545543	5637069	1 - Most Connected	1 - Most Connected	1 - Most Connected	1 - Most Connected	No
35	550776	5630949	2 - Partially Connected - Bigger Gaps	3 - Least Connected	4 - Least Connected	Least Connected	Yes
36	551130	5630189	2 - Partially Connected - Bigger Gaps	1 - Most Connected	2 - Partially Connected - Bigger Gaps	Partially Connected	No
38	549892	5630542	4 - Least Connected	3 - Least Connected	2 - Partially Connected - Bigger Gaps	Least Connected	Yes
39	550531	5628689	2 - Partially Connected - Bigger Gaps	Partially Connected	3 - Partially Connected - Smaller Gaps	Partially Connected	No
43	555476	5623684	2 - Partially Connected - Bigger Gaps	3 - Least Connected	3 - Partially Connected - Smaller Gaps	Partially Connected	No
47	563287	5612893	4 - Least Connected	3 - Least Connected	4 - Least Connected	Least Connected	No

Site	Easting	Northing	2020 Wetland Group	2021 Wetland Group	2022 Wetland Group	Modal Group	Bird Surveys
48	562874	5612685	3 - Partially Connected - Smaller Gaps	Partially Connected	ND	Partially Connected	No
49	563443	5608264	4 - Least Connected	3 - Least Connected	4 - Least Connected	Least Connected	Yes
51	567072	5601686	3 - Partially Connected - Smaller Gaps	Partially Connected	2 - Partially Connected - Bigger Gaps	Partially Connected	No
59	543772	5638706	1 - Most Connected	1 - Most Connected	1 - Most Connected	1 - Most Connected	No
62	544859	5639039	3 - Partially Connected - Smaller Gaps	3 - Least Connected	3 - Partially Connected - Smaller Gaps	Partially Connected	Yes
64	546804	5635861	1 - Most Connected	1 - Most Connected	1 - Most Connected	1 - Most Connected	No
68	545273	5635944	1 - Most Connected	1 - Most Connected	1 - Most Connected	1 - Most Connected	No
69	544325	5639373	4 - Least Connected	3 - Least Connected	2 - Partially Connected - Bigger Gaps	Least Connected	Yes
70	551389	5627697	2 - Partially Connected - Bigger Gaps	1 - Most Connected	1 - Most Connected	1 - Most Connected	No
71	550149	5630945	2 - Partially Connected - Bigger Gaps	1 - Most Connected	2 - Partially Connected - Bigger Gaps	Partially Connected	Yes
110	542996	5638520	3 - Partially Connected - Smaller Gaps	Partially Connected	3 - Partially Connected - Smaller Gaps	Partially Connected	No
126	549517	5631250	2 - Partially Connected - Bigger Gaps	Partially Connected	4 - Least Connected	Partially Connected	No
127	549090	5631267	4 - Least Connected	3 - Least Connected	2 - Partially Connected - Bigger Gaps	Least Connected	Yes

Site	Easting	Northing	2020 Wetland Group	2021 Wetland Group	2022 Wetland Group	Modal Group	Bird Surveys
128	548571	5631699	2 - Partially Connected - Bigger Gaps	Partially Connected	3 - Partially Connected - Smaller Gaps	Partially Connected	No
129	528755	5654469	4 - Least Connected	Partially Connected	3 - Partially Connected - Smaller Gaps	Partially Connected	No
130	528565	5654310	2 - Partially Connected - Bigger Gaps	1 - Most Connected	1 - Most Connected	1 - Most Connected	No
131	528247	5655396	4 - Least Connected	3 - Least Connected	2 - Partially Connected - Bigger Gaps	Least Connected	Yes
132	533588	5652117	1 - Most Connected	1 - Most Connected	1 - Most Connected	1 - Most Connected	Yes
137	550568	5629167	3 - Partially Connected - Smaller Gaps	Partially Connected	3 - Partially Connected - Smaller Gaps	Partially Connected	No
140	543498	5641456	ND	Partially Connected	ND	NA	No
141	540750	5645785	ND	Partially Connected	3 - Partially Connected - Smaller Gaps	Partially Connected	Yes
142	536898	5649710	ND	3 - Least Connected	3 - Partially Connected - Smaller Gaps	NA	Yes
143	531008	5653564	ND	3 - Least Connected	3 - Partially Connected - Smaller Gaps	NA	Yes
144	523973	5657202	ND	3 - Least Connected	2 - Partially Connected - Bigger Gaps	NA	Yes
145	523706	5657294	ND	1 - Most Connected	1 - Most Connected	1 - Most Connected	Yes

7.2 Appendix 2: Detailed methods of fieldwork and analysis

2 Methods

We conducted research in a total of 38 wetlands (Figure 6), working over three years from 2020 to 2022, with the majority of fieldwork completed in 2021 and 2022. In 2020, only 30 wetlands were studied and eight new wetlands were picked in 2021 to better represent the different types of wetland present in the Columbia Wetlands ecosystem. Wetlands were chosen for inclusion in this study based on local expert knowledge and previous work conducted in the Columbia Wetlands.

2.1 Fieldwork

2.1.1 Wetland Hydrology

We measured water levels (m) and water temperature at individual wetlands using HOBO U-20 (HOBO by Onset, Cape Cod, Massachusetts, USA) water level loggers, installed each year in May and removed in October, with pressure (later converted to water depth) and temperature being recorded every four hours. All measurements were corrected with a barometric pressure sensor located at Brisco. In 2021 and 2022 there were equipment failures, resulting in data from 37 and 36 wetlands respectively. Similarly, one or both of the two water level loggers in the Columbia River were lost in all three years, so for Columbia River water depth we instead used a publicly available dataset from the Environment and Climate Change Canada hydrometric station on the Columbia River at Nicholson (cite this!).

2.1.2 Levee Gaps and Beaver Dams

We identified potential locations of beaver dams, beaver lodges, and levee gaps within the wetland, and within 10m, 20m, and 30m of the 38 study wetlands using ArcGIS Pro 2.8.0 and a combination of orthophotos, satellite imagery, LiDAR imagery, and digital elevation models (Airborne Imagery, 2015; Forest, Lands, and Natural Resource Operations and Rural Development, Geo BC, 2018). These buffer distances were included as in several instances we found that the dam(s) responsible for holding water into the wetland were not within the boundaries of the wetland itself. From the imagery, using ArcGIS Pro 2.8.0 tools, we measured the length of beaver dams, the perimeter length (m) and area (m^2) of each wetland and levee gaps. All gaps were included to determine the total gap width (m) in each wetland, regardless of whether these gaps were influencing water levels in the wetlands. Gaps that did not influence wetland water levels were then excluded from further analysis and 'Inflow Gaps' were summarized to determine the width of gaps influencing water levels within each wetland. Inflow gaps were determined based on characteristics visible on ArcGIS and then confirmed via in person fieldwork (Appendix 5).

Once we determined the locations of beaver dams and gaps through remote sensing, we conducted in-person fieldwork at each wetland site. In-person fieldwork was essential, as not all dams and gaps were visible from remote sensing sources, and measuring all the required dam dimensions, as well as determining how the dams or gaps affected the hydrology of the wetland itself, was not possible otherwise. All dams and gaps were visited and measured between August 2021 and May 2022, within the same flood year. This timing was important because dams and gaps could not be measured during high water. We walked and/or kayaked the perimeter of each wetland to identify beaver dams and gaps, using the remote sensing derived information as a guide for where there were likely to be dams or gaps; in some instances we located dams on the ground that were not visible through remote sensing. Once at a dam or gap location, we measured the dimensions of the feature (Appendix 6), took notes on building material, beaver activity (active, where there were signs of fresh mud or new sticks; inactive, where there were no such signs but the dam was still in good repair; and old, where the dam was no longer in good repair), water flow, and its influence on the wetland, as well as drawing a rough sketch of the feature. Preliminary digital measurements were then amended based on this ground-truthing in the field.

2.1.3 Migratory bird surveys

We conducted migratory bird surveys in 20 wetlands (Appendix 1). We found that time of day did not have a consistent or large impact on the numbers of species and birds present at a site, after which point we surveyed sites for as long as possible on a single day. In case diurnal patterns are significant, however, with some sites maybe being chosen as roost sites and some as feeding sites, we made sure to vary the times of day at which we surveyed each site, and will take time of survey into account in my analysis. We did not survey in inclement weather (e.g., heavy snow and rain, fog), but on days when such weather was inconsistent, we did conduct surveys in the periods of suitable weather. We surveyed each site using binoculars and a spotting scope, and took photographs of birds present, for a minimum of 15 minutes up to however long it took to count and identify to species (if possible) all waterfowl and raptors using the wetland. We also recorded weather conditions, human disturbances, and other factors that might have affected the presence of waterfowl. I also entered count data on eBird.

We have done five or six spring and fall migratory waterfowl counts at each of the sites since we began. Larson *et al.* (2020) concluded that due to the variability of waterfowl count data, three surveys were the minimum required for data analysis.

7.3 Appendix 3: Incidental bird observation data

See attached excel file

7.4 Appendix 4: Migratory waterbird survey data

See attached excel file

7.5 Appendix 5: List of observed Species at Risk birds

Scientific Name	English Name	Biogeoclimatic Units	Provincial	BC List	Global	COSEWIC	SARA
Botaurus lentiginosus	American Bittern	BG; BWBS; CDF; CWH; ICH; IDF; MS; PP; SBPS; SBS	S3B,SNRN (2015)	Blue	G5 (2016)		
Riparia riparia	Bank Swallow		S4?B (2022)	Yellow	G5 (2016)	T	1-T (2017)
Hirundo rustica	Barn Swallow	BAFA; BG; BWBS; CDF; CWH; ESSF; ICH; IDF; IMA; MH; MS; PP; SBPS; SBS; SWB	S4B (2022)	Yellow	G5 (2016)	SC	1-T (2017)
Chlidonias niger	Black Tern	BG; BWBS; CDF; CWH; ESSF; ICH; IDF; MS; PP; SBPS; SBS	S2S4B (2023)	Blue	G4G5 (2016)	NAR	
Larus californicus	California Gull	BG; BWBS; CDF; CWH; ICH; IDF; MS; PP; SBS	S1B,SNRN (2022)	Red	G5 (2016)		
Chordeiles minor	Common Nighthawk	BG; BWBS; CDF; CWH; ESSF; ICH; IDF; MH; MS; PP; SBPS; SBS; SWB	S3S5B (2022)	Blue	G5 (2016)	SC	1-SC (2023)
Nannopterum auritum	Double-crested Cormorant	BWBS; CDF; CWH; ICH; IDF; PP; SBPS; SBS	S3S4 (2015)	Blue	G5 (2016)	NAR	
Podiceps nigricollis	Eared Grebe	BAFA; BG; BWBS; CMA; CWH; ESSF; ICH; IDF; IMA; MH; MS; PP; SBPS; SBS	S3B (2015)	Blue	G5 (2016)		
Chondestes grammacus	Lark Sparrow	BG; BWBS; CDF; CWH; ICH; IDF; MS; PP; SBPS; SBS	S2S4B (2022)	Blue	G5 (2016)		
Falco peregrinus	Peregrine Falcon	BG; BWBS; CDF; CWH; ESSF; ICH; IDF; MS; PP; SBS; SWB	S3 (2015)	No Status	G4 (2016)	SC	1-SC
Phalaropus lobatus	Red-necked Phalarope	BG; BWBS; CDF; CWH; ICH; IDF; MS; PP; SBPS; SBS; SWB	S3B,SNRM (2023)	Blue	G4G5 (2016)	SC	1-SC (2019)

Buteo lagopus	Rough-legged Hawk	BAFA; BG; BWBS; CDF; CWH; ESSF; ICH; IDF; IMA; MS; PP; SBPS; SBS; SWB	S3N (2015)	Blue	G5 (2016)	NAR	
Cygnus columbianus	Tundra Swan		S3N (2015)	Blue	G5 (2016)		
Aechmophorus occidentalis	Western Grebe	BG; BWBS; CDF; CWH; ICH; IDF; MS; PP; SBPS; SBS	S1S2B,S2N (2023)	Red	G5 (2016)	SC	1-SC (2017)

7.4 Appendix 6: Water quality data

See attached excel file