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

Hydrologic Mapping of Wetland Communities to Determine Which Ones are most likely to Lose Water that Species at Risk Depend Upon

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Kootenay Connect: Columbia Wetlands Focal Area

Year 2 (2020-2021)

Project: 2CW Hydrologic Mapping

Kootenay Connect is a project facilitated by the Kootenay Conservation Program

The 2CW Hydro Mapping project coordinated by the Columbia Wetlands Stewardship Partners (CWSP) as a project of Kootenay Connect, is composed of three subprojects, two of which are funded by Kootenay Connect. This is an ambitious project to identify and map the floodbasins in the Columbia Wetlands that are vulnerable to drought and climate change and to determine if and where the loss of water can be mitigated by local conservation actions. The three subprojects include (1) **A remote sensing observation-based assessment of floodplain hydroperiod and wetland vulnerability analysis** of 2600 ha of wetlands to determine if remote sensing can determine if the area of permanent open water has changed in the last 20 year compared to earlier years; (2) **Upper Columbia Wetland Vulnerability Assessment Project** is an analysis to hydrologically characterize the different types of wetlands and determine which wetlands are most vulnerable to drought and loss of water overwinter and (3) **Importance of Ground Water to the Hydrologic Mass Balance of Columbia Wetlands** provides an assessment of the importance of ground water to the wetlands during spring, summer and fall seasons. Together these projects will enable the hydrologic team to develop hydrologic budgets of the different types of wetlands and determine those wetlands most vulnerable to drought.

This project is an on-going one since one years' analysis will not provide definitive quantitative data on the hydrologic flows. However, it has enabled us to identify several wetlands that have lost area of permanent open water since 2003 and hence are vulnerable to loss of water in the future. It has enabled us to determine that there are 6 major types of floodbasin wetlands based on their hydroperiods, some of which are vulnerable to drought. And it has enabled us to determine the importance of ground water to the hydrologic budgets in 36 wetlands.

We give a brief summary of results for each subproject and attach a technical report from the two funded by Kootenay Connect.

1) A remote sensing observation-based assessment of floodplain hydroperiod and wetland vulnerability

The over-arching objective of this project led by Dr. Chris Hopkinson of the University of Lethbridge was to develop and report on the data, methods and results of a proof-of-concept study to identify wetlands at risk by evaluating wetland hydroperiod change in the Upper Columbia River Floodplain. See Appendix 1 for a detailed account of the research undertaken[1].

Increasing temperatures and depleting snowpack in the mountainous Kootenay Region of British Columbia, Canada is expected to impact floodplain wetland extent and function along the Columbia River. The objective of this study was to determine floodplain hydroperiod for a section of the Upper Columbia River wetlands complex using time series satellite image

[1] The work is also documented in Hopkinson C., Fuoco B, Grant T., Bayley S.E., Brisco B., MacDonald, R. Wetland Hydroperiod Change Along the Upper Columbia River Floodplain, Canada, 1984 to 2019. *Remote Sensing*. 2020; 12(24):4084. https://doi.org/10.3390/rs12244084 YouTube video abstract: **https://youtu.be/kteXzzx4lWg**

observations and binary open water mask extraction. A mid pixel resolution (30m) optical satellite image time series of 60 clear sky scenes from the Landsat Thematic Mapper (TM) and Operational Land Imager (OLI) sensors were used to map temporal variations in floodplain open water wetland extent during the April to October hydrologically active season from 1984 to 2019 (35 years). The hydroperiod from the first 30 scenes (T1: 19 years) was compared to the second 30 (T2: 16 years) to identify changes in the permanent and seasonal open water bodies. The seasonal variation in open water extent and duration were similar across the two time periods but the permanent water body extent diminished by ~16% (or ~4% of total floodplain area). A simple linear model ($r2 = 0.87$) was established to predict floodplain open water extent as a function of river discharge downstream of the case study area. This suggests that most of the loss of permanent open water bodies is due to the decline in the peak seasonal flood. The loss of 16% of the area of permanent open water area is supported by the findings of Brahney et al (2017)[2] who found a ~ 13% decline in the flows of the upper Columbia River.

2). The goal of the Upper Columbia Wetland Vulnerability Assessment project, led by Dr. Ryan MacDonald, is to determine the various types of wetlands in the upper Columbia Wetlands based on their hydrology, to determine which types of wetlands are more vulnerable to drought (and climate change) and to assess which wetlands may be amenable to conservation actions to prevent the loss of water. The project has started to classify the wetlands based on their hydrologic and morphological characteristics. In May 2020, the team installed water level recorders in 37 wetlands, 2 in the main river, and 4 ground water installations to monitor groundwater input in 4 sites. Precipitation and evaporation are also available from local data and together all of these will be used to construct hydrologic budgets of the monitored wetlands. Analysis of the hydroperiod in 2020 (Yr1) has indicated that there are 6 main types of wetlands based on their hydrologic responses to the rising and falling limbs of the seasonal flood. Hydroperiods in two types of wetlands appear to be totally determined by the peak floods and thus are unlikely to be amenable to conservation actions to mitigate the loss of water. Levees which isolate the wetlands from the main river and differences in groundwater sources modify the hydrologic inflows and outflows in 4 types of wetlands. These are likely the wetlands which may be more amenable to mitigation actions by local conservation groups. Combining the hydrologic monitoring in Year 2 of the Kootenay Connect project, the mapping from the Year 1 Kootenay Connect Wetland Mapping project and the drone analysis of beaver dams will enable us to select wetlands which we can use to install artificial beaver dams or enhance natural beaver dams in Year 3 of the Kootenay Connect project. The 6 hydrologically different types of wetlands are illustrated below.

[2] Brahney, J., Weber, F., Foord, V., Janmaat, J., Curtis, Paul. J. (2017). Evidence for a climate-driven hydrologic regime shift in the Canadian Columbia Basin. Canadian Water Resources Journal 42(2) 179-192.

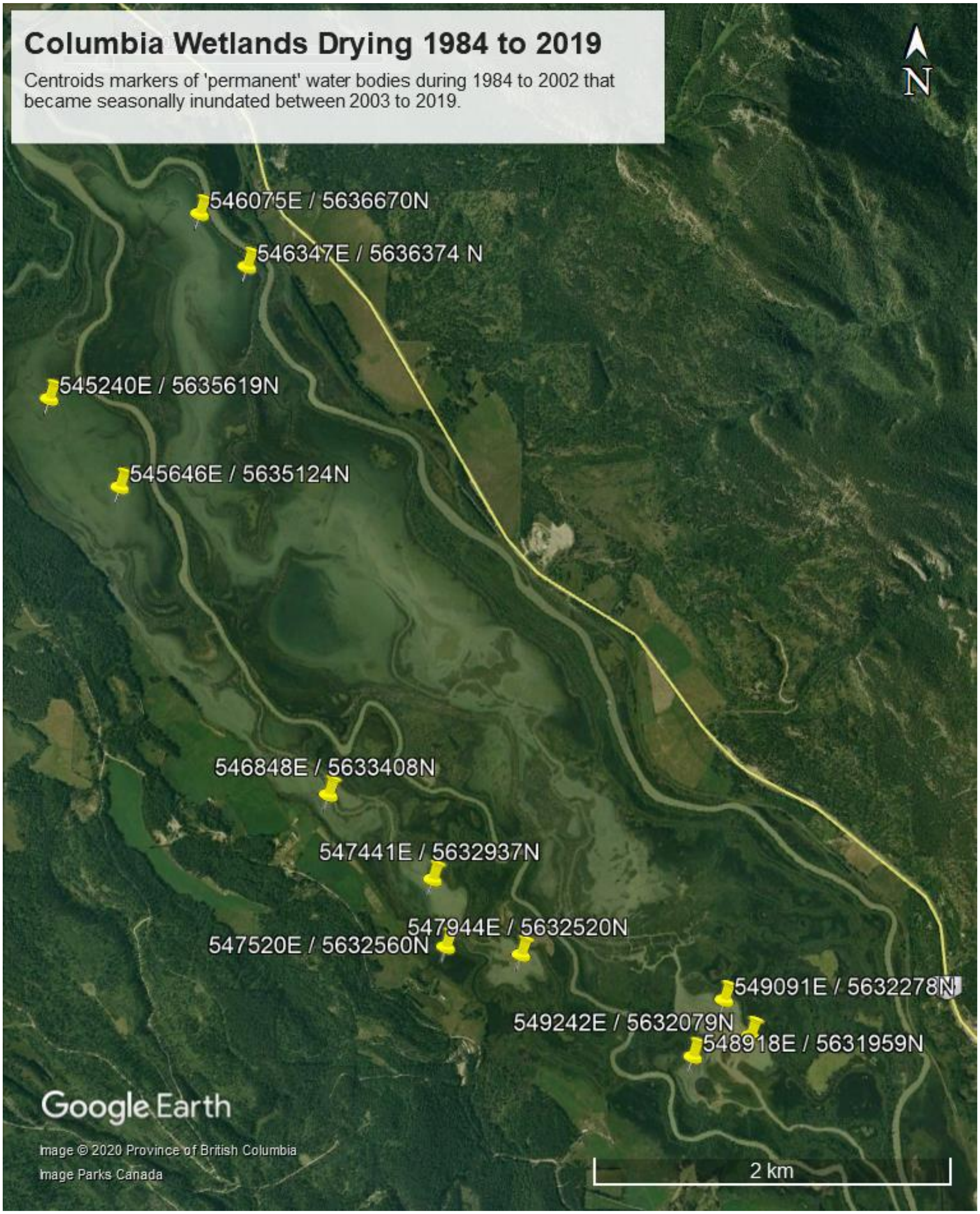

Figure 1. Map of 11 Columbia Wetlands between Brisco and Spillimacheen, BC that have lost permanent open water in the period 2003-2019 compared to the period 1984-2002.

Wetlands in the lowlands of mountain landscapes receive their water primarily from streams and groundwater discharge. Given that the wetlands are in the upper Columbia River floodplain, near the headwaters of both streams and groundwater flow systems, the upgradient watersheds of either water source are relatively small, which makes the region more vulnerable to changes in climate. However, at the wetland-scale, further evaluation is needed to determine whether a wetland is more (or less) vulnerable depending on whether it is predominantly connected via surface or subsurface pathways. All wetlands in the upper Columbia River floodplain will likely be vulnerable to hydrologic change, but at different time scales given that both streams and groundwater flow systems are snowmelt-dominated. Appendix 2 provides a summary of this work thus far.

Recommendations for future work:

- Site investigation of select wetlands to better understand water sources and predominate pathways (decreasing the number of river-dominated wetlands being monitored).
- Analyses of shallow groundwater levels to support conceptual understanding.
- Calculate wetland-scale water balances by incorporating additional morphologic and meteorological data.
- Refine wetland groupings and statistical analyses.
- Develop a series of maps that outline vulnerable wetlands based on their hydrologic characteristics.

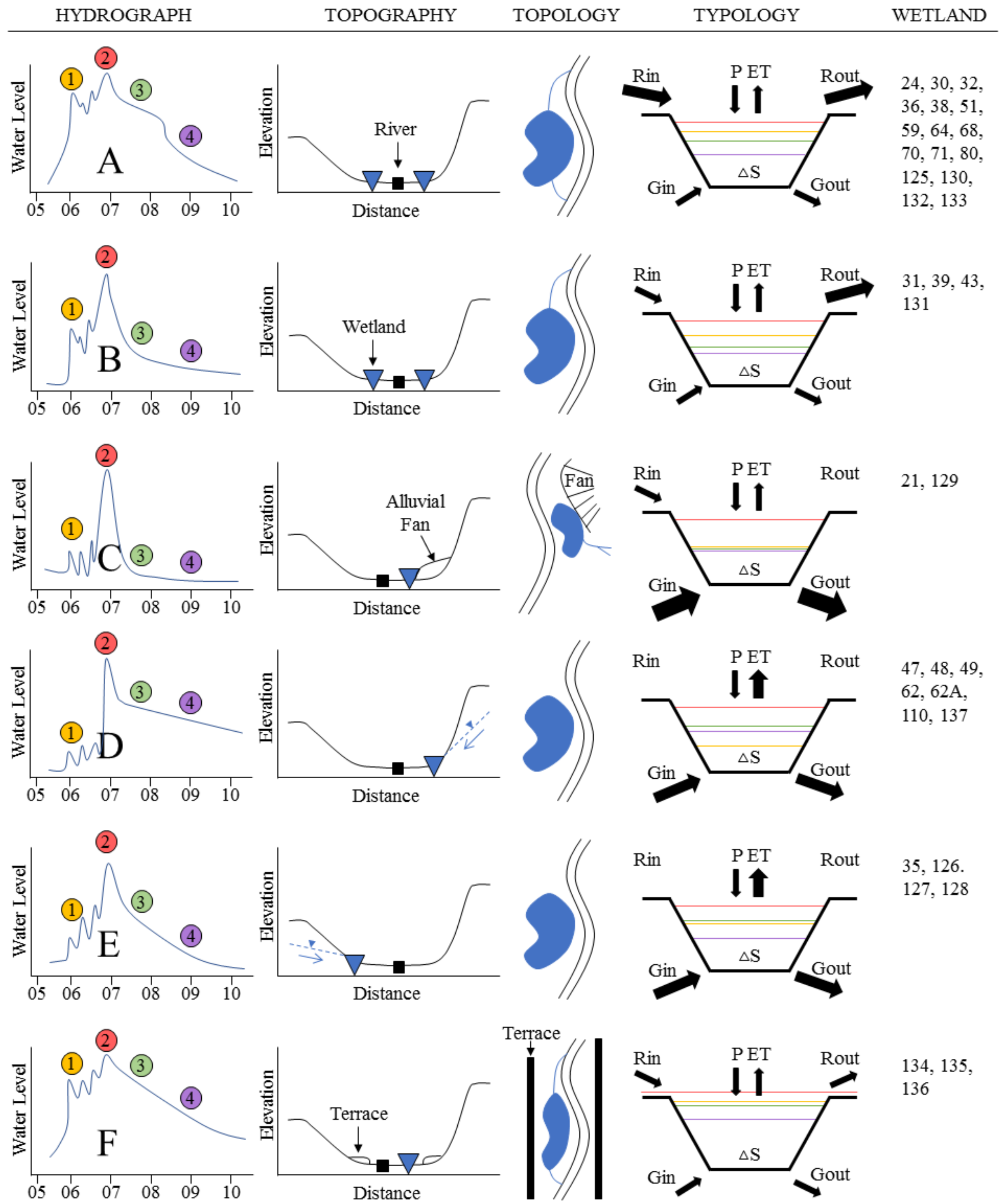

Figure 2 Conceptual diagram of wetland groups' water level response, topographic location, hydrologic connectivity (topology), and predominant water balance fluxes (typology).

3) Importance of Ground Water to the Hydrologic Mass Balance of Columbia Wetlands Project

This project led by Dr. Rebecca Rooney of the University of Waterloo, has collected water from the Columbia wetlands in 2019 and 2020 in spring, summer and fall seasons. The stable isotopes of oxygen and hydrogen were analysed to determine how much ground water (%) is in the wetlands in spring, summer and fall. This project is funded elsewhere and has no summary at this time. However, results from the 2019 season are available and shown in Figure 3 below.

The results suggest that ground water is very abundant in the Columbia Wetlands and generally increases from spring to fall. Once the analysis is complete, the data will be used in the previous projects to help complete the wetland mass balance and to select sites that may be amenable to construction of artificial beaver dams.

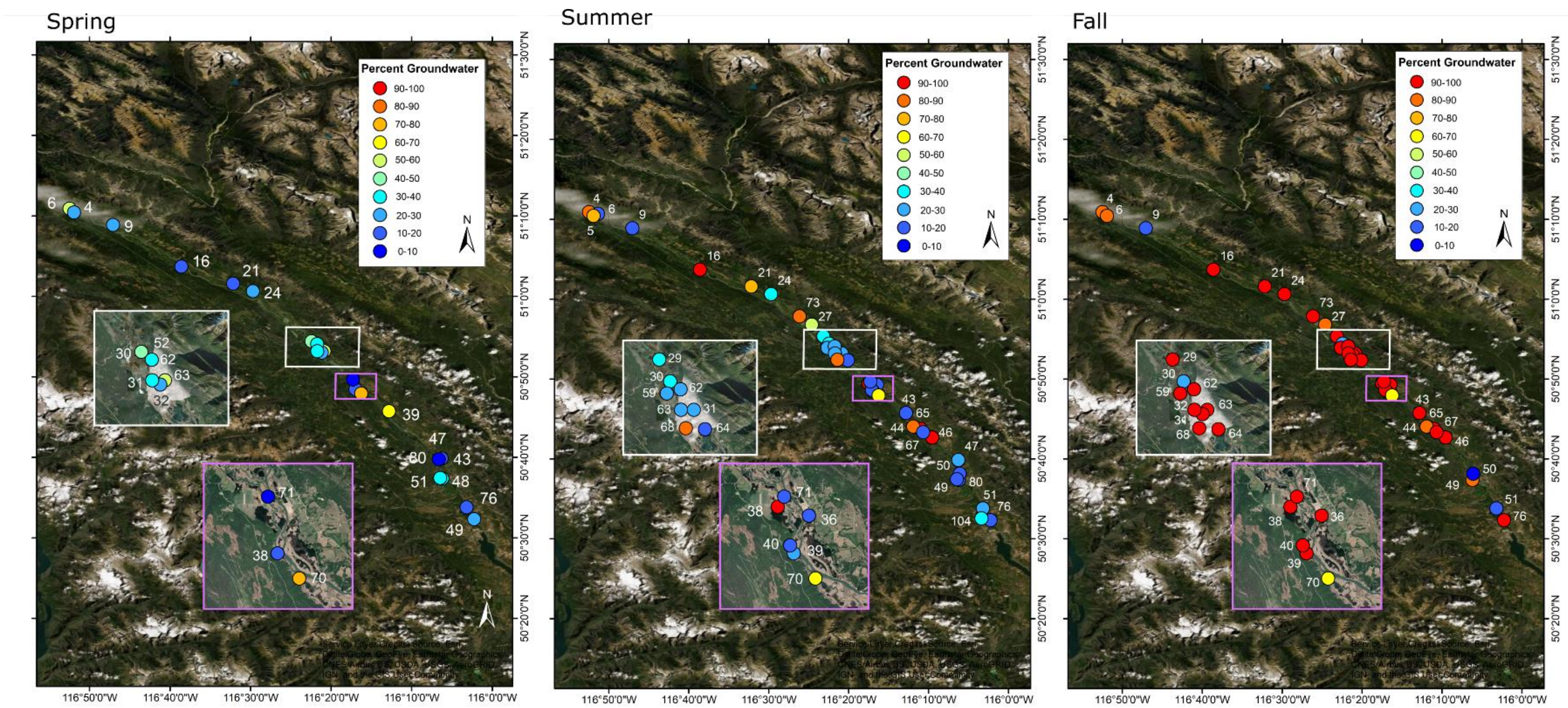

Figure 3. Maps displaying the proportion of ground water in the Columbia Wetlands during the spring, summer and fall of 2019. Data from 2020 are not available yet.