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Vulnerability Assessment of the Bench Wetlands in the Upper Columbia River Basin

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1 Introduction

Wetlands are ecosystems with saturated soils and hydrophytic vegetation that provide several important ecological services. Wetlands deliver critical hydrological functions, such as mitigating peak flows (Ferreira et al., 2020), recharging groundwater and increasing soil infiltration (Rojas et al., 2022), and increasing low flows (Kadykalo and Findlay, 2016) reducing the risk of droughts (Wu et al., 2023). Wetlands also influence water quality, by retaining nutrients (Malerba et al., 2022; Hansson et al., 2005), filtering waters (Gonzalez-Flo et al., 2023; Hambäck et al., 2023), and reducing sediment (Tanveer et al., 2021). Wetlands increase biodiversity (Hansson et al., 2005) and provide necessary habitat to a variety of birds, such as to migrating water fowl (Darvill, 2020). Further, wetlands provide a nature-based approach to carbon sequestration, helping mitigate the effects of climate change (Taillardat et al., 2020).

However, while wetlands may play a vital role in the fight against climate change, amongst providing many other ecosystem services, these ecosystems are also susceptible to the impacts of a changing climate due to their dependency on local hydrologic patterns. Increases in global air temperature are already affecting hydrology, particularly in snow-dominated watersheds in North America where mean annual river runoff has been found to be increasing (Milly et al., 2005). This is paired with a change in the timing of flows, where spring peak flows are occurring earlier and winter base flows are higher due to more precipitation occurring as rain instead of snow, resulting in reduced summer and autumn flows when water demands are the highest (Rosenzweig et al., 2007). This is especially evident in mountainous regions which are likely to experience changes in air temperature and precipitation at an accelerated rate compared to the global land average (Pepin et al., 2022). Within the Rocky Mountains, there has been an observed reduction in the winter snowpack (Pederson et al., 2011), particularly in lower to mid-elevation areas that are no longer remaining below freezing levels throughout the winter (Almonte and Stewart, 2019). It is expected that these changes will impact the local hydrologic cycle for watersheds in the Canadian Rockies, advancing snowmelt, increasing the number of snow-free days, and increasing stream flows that will occur earlier in the season (Fang and Pomeroy, 2020).

These changes may compound existing land use effects on wetlands as wetlands are intrinsically linked to the surrounding hydrology. This may occur through surface water, groundwater, or snow or rain water pathways, so changes to the timing, duration, or magnitude can alter a wetland's water balance (Poff et al., 2002; Bertassello et al 2018). In particular, mountainous wetlands tend to be particularly sensitive to climatic variations, especially when they are mostly dependent on precipitation for water inputs or groundwater provided by fairly small watersheds (Winter, 2000). In general, the smaller the contributing watershed, the most vulnerable the wetland is to the effects of climate change (Winter, 2000), and the smaller the wetland's surface area the more sensitive it is to climatic fluctuations (Kim and Park, 2020).

Within the Upper Columbia Wetland, an area known for its undammed and relatively natural floodplain wetlands, there is a series of wetlands colloquially known as the Bench Wetlands that exist along a benched hillside in the upland area on the west side of the Columbia Valley along the base of the Purcell Mountains. These wetlands have faced numerous stressors, such as forestry, ranching, development (Personal Communication, Suzanne Bayley), and many appear to have dried up, particularly in the more southern extent. While these wetlands may be smaller than the floodplain wetlands in the valley bottom, these small wetlands are still extremely important, as smaller wetland ecosystems can provide an ecological network known as a wetlandscape (Kim and Park, 2020; Kim et al., 2022) which can include both connected (either to a stream or a lake) and disconnected wetlands (i.e. those that do not appear to have any surface water connections). Seasonal fluctuations in weather and resulting variations in the local hydrology can alter the size, shape, and connectivity of wetlands in a wetlandscape, which can in turn further alter the surrounding hydrology (Bertassello et al., 2018). This is even evident in the disconnected wetlands on the landscape which, primarily through groundwater pathways, have been shown to mitigate peak flows and increase low flows of nearby streams (Golden et al., 2016).

In the current study, we examine the Bench Wetlands in the Columbia Valley to assess their vulnerability to climate change and determine what drivers might be important in affecting their vulnerability. This study will be used to guide future monitoring, modelling, and restoration efforts.

2 Study Area

The study area includes the bench wetlands on the eastern slopes of the Purcell Mountains between Canal Flats and Spillimacheen, BC, within the Rocky Mountain trench (Figure 1). The study area was defined as an upland area between approximately 785 m and 1871 m with a median elevation of 1063 m. The study area was delineated using elevation and topographic features in GIS and is approximately 668 km^2 and 100 linear km from N to S.

The study area is 88.8% forested with 50.2% falling in the IDFdk5 BEC zone (Columbia Dry Cool Interior Douglas-fir; Figure 2), 26.8% as MSdk (Dry Cool Montane Spruce), 13.2% IDFxk (Very Dry Cool Interior Douglas-fir), 5.6% as ICHmk5 (Interior Cedar – Hemlock Moist Cool), 4.0% as IDFdm2 (Kootenay Dry Mild Interior Douglas-fir), 0.2% ESSFdk2 (Columbia Dry Cool Engelmann Spruce – Subalpine Fir), and 0.01% MSdw (Dry Warm Montane Spruce).

Most of the study area has a NE aspect (29.2%) and almost none is considered truly flat (0.25%), while the remaining study area is split into the other aspects relatively evenly (between 5.95% to 16.1% each aspect). The area is not particularly steep, with 35.7% of the area having a slope of less than 10%, and 31.3% of the area with a slope of 11-20%.

Many 5th and 6th order streams originate in the Purcell Mountains and travel through the study area, including Spillimacheen River and Bugaboo, Horsethief, and Toby Creeks, though these do to intersect any of the wetlands in the area; Templeton River and Dunabr, Goldie, Driftwood, Salter, Marion, Wilmer, Hurst, Castor, Brady, Neave, and Rand Creeks are all smaller tributaries that intersect with wetlands in the study area.

The study area falls within the Upper Columbia watershed, which is the greater region used in developing the regional climate model from which the water balance equations were developed. This area includes the Rocky Mountain trench and the mountain ranges to the east including the headwater of the Columbia River and Kootenay River. This region extends from below 800 m at Donald, BC to over 3300 m at the highest peaks along the Continental Divide and in the Selkirk Mountains.

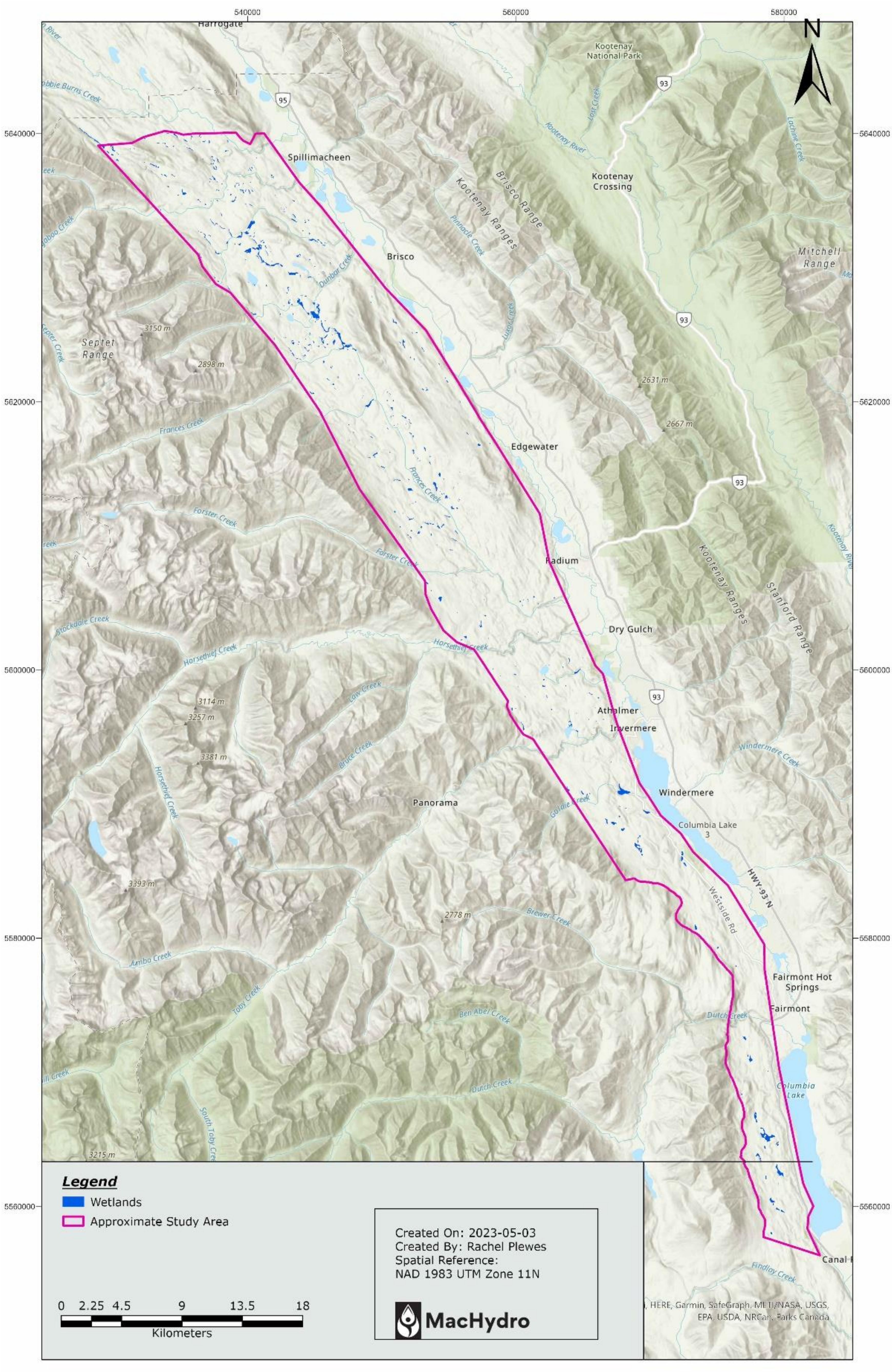


Figure 1. Study area showing the Bench Wetlands on the west side of the Rocky Mountain Trench ranging from Canal Flats to north of Spillimacheen, BC

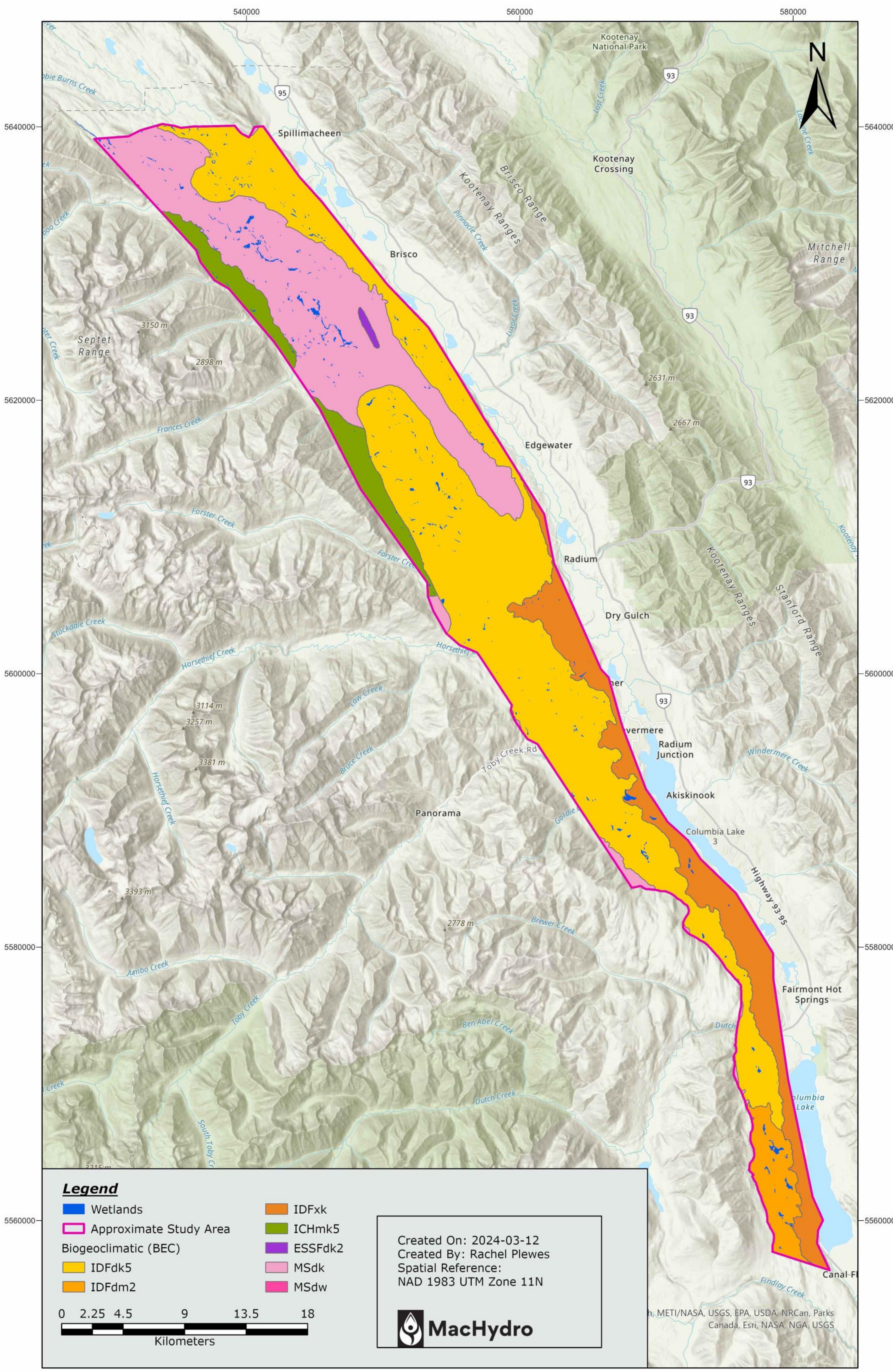


Figure 2. BEC zones within the study area, including IDFdk5 (Columbia Dry Cool Interior Douglas-fir), IDFdm2 (Kootenay Dry Mild Interior Douglas-fir), IDFxk (Very Dry Cool Interior Douglas-fir), ICHmk5 (Interior Cedar -- Hemlock Moist Cool), ESSFdk2 (Columbia Dry Cool Engelmann Spruce – Subalpine Fir), MSdk (Dry Cool Montane Spruce), and MSdw (Dry Warm Montane Spruce).

3 Methods

3.1 Vulnerable Wetland Identification

Within the study area, watersheds contributing to wetlands were delineated using Freshwater Atlas wetlands, and a total of 443 wetland watersheds were delineated. An index of watershed size was determined where watershed area was divided by the wetland area. This is used as a proxy for determining the potential external influence the surrounding watershed has on the wetland, where the smaller the watershed and relatively bigger the wetland, the greater the influence the surrounding landscape could have on the wetland.

Next the aquatic hazard was determined, which was calculated as a weighted sum of road density (km/km^2) for the watershed, equivalent clearcut area (ECA; %), and the percent riparian area disturbed (%). To determine road density, the Digital Road Atlas and Forest Tenure Road Segment Lines were combined and used to calculate the road density for the full watershed around each wetland. ECA was determined from the Vegetation Resources Inventory (VRI) database where consolidated cutblocks forest types with harvest dates were combined and the ECA was calculated based on the projected tree height. Riparian area disturbance was derived for each wetland with a 30 m buffer in which any harvested blocks (or anywhere with an ECA over 0) were considered disturbed and the total area was divided by the wetland area. Road density, ECA, and riparian disturbed were each scaled between 0 and 1 and then summed to determine the aquatic hazard.

Drainage ratio, or the size of the contributing area divided by the wetland area, was calculated for each wetland. To determine vulnerability to climate change, wetlands with a drainage ratio of less than 100 and an aquatic hazard of greater than 0.4 were selected. These results were used to rank wetlands in terms of their overall level of disturbance, indicating vulnerability.

3.2 Vulnerable Wetland Drivers

To assess potential drivers behind vulnerable wetlands, the wetlands were classified as either interesting a stream, within 30 m of a lake, or isolated. Wetlands were also tabulated based on the BEC zone classification that they fell under. To further assess the influence of climate, the study area was subdivided into three zones based on watershed licensing boundaries (Figure 3). The north zone included the Forster creek watershed and all watersheds northwest of Radium. The central zone was comprised of the four watersheds of Horsethief, Wilmer, Neave, and Toby creeks. The remaining watersheds that are south of Invermere define the south zone. The south zone included watersheds that drain into Windemere Lake, Columbia River, and Columbia Lake. Wetland geographic locations within these regions were assessed based on connectivity to streams and vulnerability.

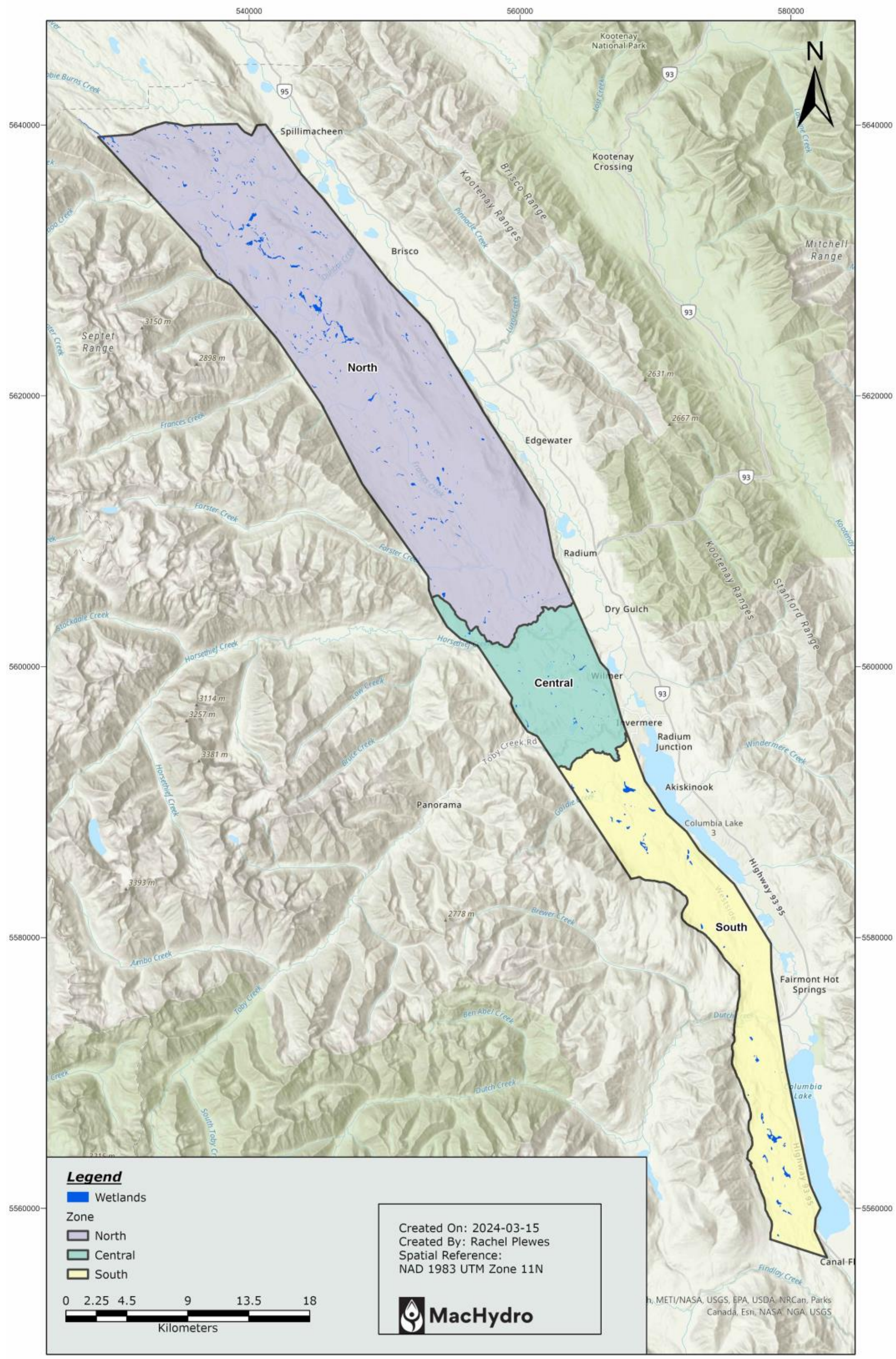


Figure 3. Northern (purple), central (green), and southern (yellow) zone subdivisions of the study area.

3.3 Hydrological Modelling

This assessment also used a modelling tool to evaluate wetland vulnerability under climate change. Please refer to the Vulnerability Assessment of the Columbia Floodplain Wetlands for full methods on model development and refinement.

3.3.1 Model Formulation

The semi-distributed hydrological model used in this study is an adapted version of the HBV-EC model, emulated within the Raven Hydrological Modelling Framework version 3.8 (Craig et al., 2023). The model simulates streamflow and other hydro-climatic variables (i.e. snowmelt, evaporation, etc.) at a daily timestep. The model spatially distributes daily minimum and maximum air temperature, precipitation, and relative humidity from all weather stations across the study region. The model simulates major hydrological processes including canopy interception, snow accumulation and melt, evaporation, soil infiltration, percolation, and baseflow, as well as surface runoff. Major processes are described below, while a comprehensive discussion of model algorithms can be found in Bergström (1992), Jost et al. (2012), and Chernos et al. (2020).

In the hydrological model, water inputs occur as precipitation, which is partitioned into rain or snow following the HBV linear transition based on air temperature. Precipitation interception by the forest canopy is estimated as a function of Leaf-Area Index (LAI; Craig et al., 2020; Hedstrom and Pomeroy, 1998). Snowmelt is calculated using a spatially corrected temperature index model, which accounts for aspect, slope, and day length (Jost et al., 2012, Craig et al, 2020). Glacier melt is estimated following the HBV routines (Craig et al., 2020). Potential evapotranspiration is estimated using the Priestley–Taylor equation over land and Hargreaves (1985) over water and varies between vegetation types. Once water infiltrates the three-layer soil, it moves downwards through percolation and upwards through capillary rise. Soil water becomes surface runoff (i.e. streamflow) through (faster) interflow and (slower) baseflow pathways.

Small lakes were treated as lake storage with a linear rate of water release. Major lakes were treated as natural reservoirs where mass balance was calculated using storage curves derived from lake characteristics and flow attenuation coefficients. Treating a waterbody as a reservoir allows the model to simulate the mass balance of the lake and explicitly account for flow attenuation along the main channel. Both reservoirs and lakes freeze during below 0°C air temperatures, accumulate snow when frozen, and thaw once the overlying winter snowpack has melted away. In total, reservoirs were simulated at the outlet of two sub-basins to reflect Columbia Lake and Lake Windermere. Although Lake Windermere is not located at a sub-basin outlet, it was treated as such to also account for flow attenuation in the large wetland complex along the length of the Rocky Mountain Trench.

4 Results

4.1 Vulnerable Wetland Identification

Of the 443 wetlands identified in the study area, most of the wetlands were under 1 ha in size, with 258 wetlands in this size class (Figure 4). The average wetland size was 1.75 ha, and the largest wetland has an area of 31.58 ha. Of these wetlands, 47 wetlands were found to be vulnerable to the effects of climate change (Figure 5). The average vulnerable wetland size was 0.99 ha and the largest wetland was 9.18 ha. Individual vulnerable wetlands can be seen in **Error! Reference source not found.**.

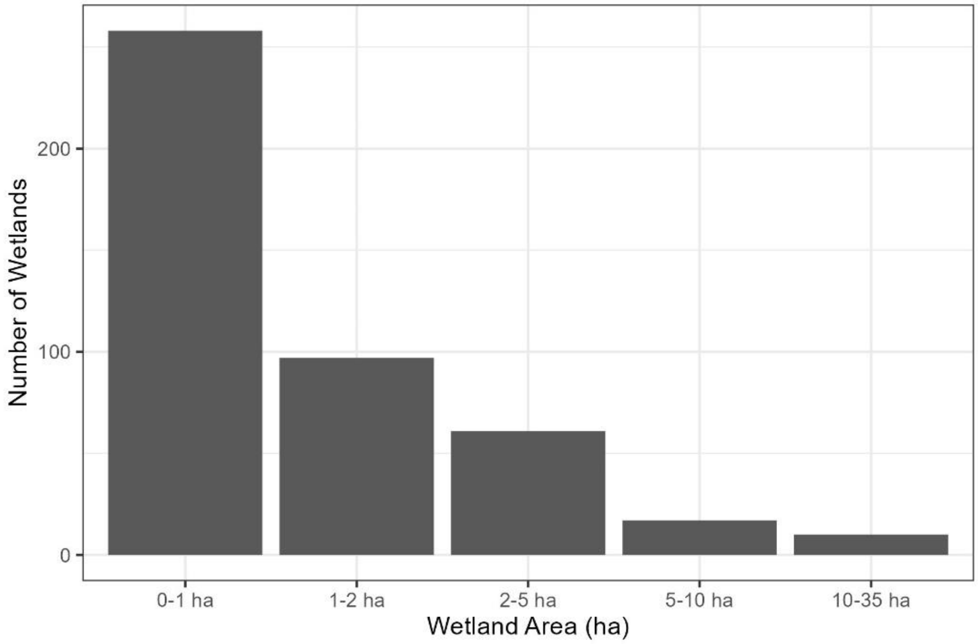


Figure 4. Area of the 443 bench wetlands.

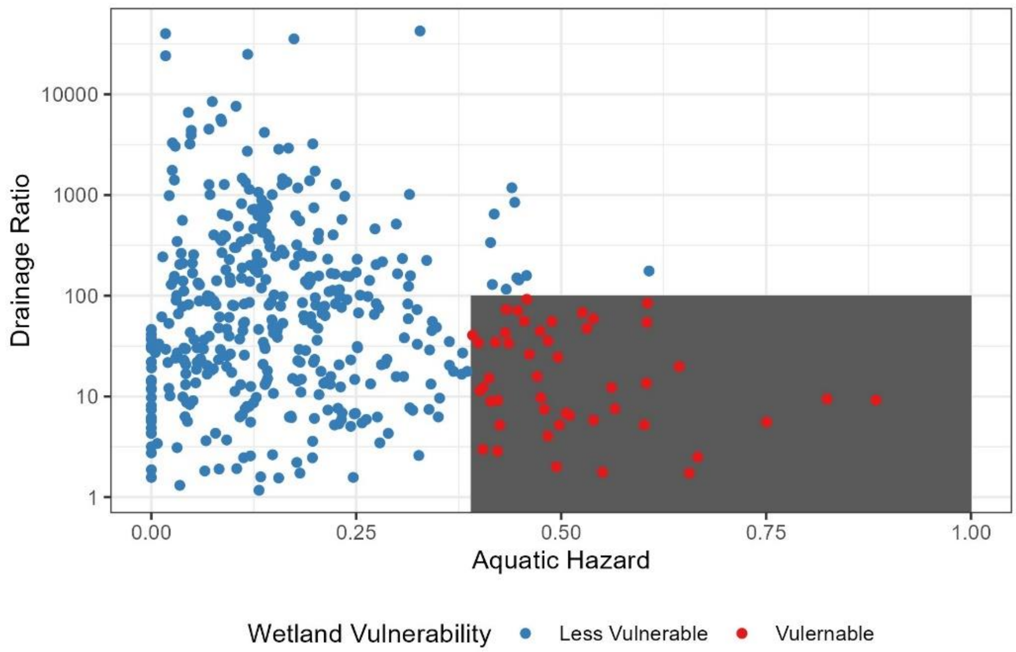


Figure 5. The vulnerability of the bench wetlands in the Columbia Valley with those that are vulnerable to the effects of climate change falling in the grey box. Vulnerability is defined as those with an aquatic hazard above 0.4 and a drainage area below 100.

4.2 Drivers of Wetland Vulnerability

4.2.1 Connectivity Drivers

Disconnection from a water body appears to be a strong driver of wetland vulnerability, as 68% of vulnerable wetlands were disconnected (Table 1). Of the non-vulnerable wetlands, only 27% were disconnected. Connection to a stream or a stream and a lake appeared to greatly reduce the vulnerability of wetlands.

Table 1. Connectivity of vulnerable and non-vulnerable bench wetlands in the Columbia Valley

	Non-Vulnerable Wetlands		Vulnerable Wetland	
Connectivity	**#**	**%**	**#**	**%**
Disconnected	107	27.0	32	68.1
Connected to stream	150	37.9	7	14.9
Connected to lake and stream	110	27.8	5	10.6
Connected to lake	29	7.3	3	6.4

4.2.2 Biogioclimatic Drivers

Association with a particular BEC zone was a more confounding variable in determining wetland vulnerability. Wetlands occurred in the five larger BEC zones in the study area, with distribution correlating to land cover for ICHmk5, IDFdk5, and IDFdm2 (Table 2). However, IDFxk showed fewer wetlands than would be expected based on land cover, and MSdk had a greater number of wetlands. Vulnerable wetlands only occurred in MSdk and ICHmk5.

Table 2. BEC zone association of vulnerable and non-vulnerable bench wetlands in the Columbia Valley.

BEC Zone	Percent area covered in study area (%)	Non-Vulnerable Wetlands		Vulnerable Wetland	
		#	%	#	%
ICHmk5	5.6	21	5.3	0	0.0
IDFdk5	50.2	204	51.5	19	40.4
IDFdm2	4.0	15	3.8	0	0.0
IDFxk	13.2	21	5.3	0	0.0
MSdk	26.8	135	34.1	28	59.6

The location of wetlands within the study area appeared to show a stronger relationship with both wetland presence and vulnerable wetlands, and explain the BEC-wetland relationship. More wetlands occur in the northern section of the study area as opposed to the southern and central regions, and all but two of the vulnerable wetlands occur in the northern region. The northern region is predominantly comprised of the MSdk and IDFdk5 BEC zones, thus the association with these two zones.

Further analysis into the connectivity of wetlands along the north-south axis revealed that most wetlands in the south and central regions were connected to either a lake or a stream or both, with only two disconnected wetlands occurring in the central region (Table 3). Further, the majority of the vulnerable wetlands occur in the northern region, with only two vulnerable wetlands in the central zone.

Table 3. Distribution of wetlands within the northern, southern, and central regions of the study area by connectivity to a water body.

Connectivity	Non-Vulnerable Wetlands			Vulnerable Wetland		
	North	Central	South	North	Central	South
Disconnected	27	2	0	30	2	0
Connected to stream	70	21	16	7	0	0
Connected to lake and stream	123	7	20	5	0	0
Connected to lake	92	10	8	3	0	0

4.3 Model Results

4.3.1 Climate Change

Results from climate scenarios show a mild overall increase in annual precipitation throughout the study area (Figure 6), though results vary by month (Figure 7). Increases in annual air temperature are more notable, with the strongest increases occurring in the SSP5-8.5 climate scenario during the second time period studied (Figure 6). Monthly air temperatures are expected to increase during every month of the year under climate change (Figure 7).

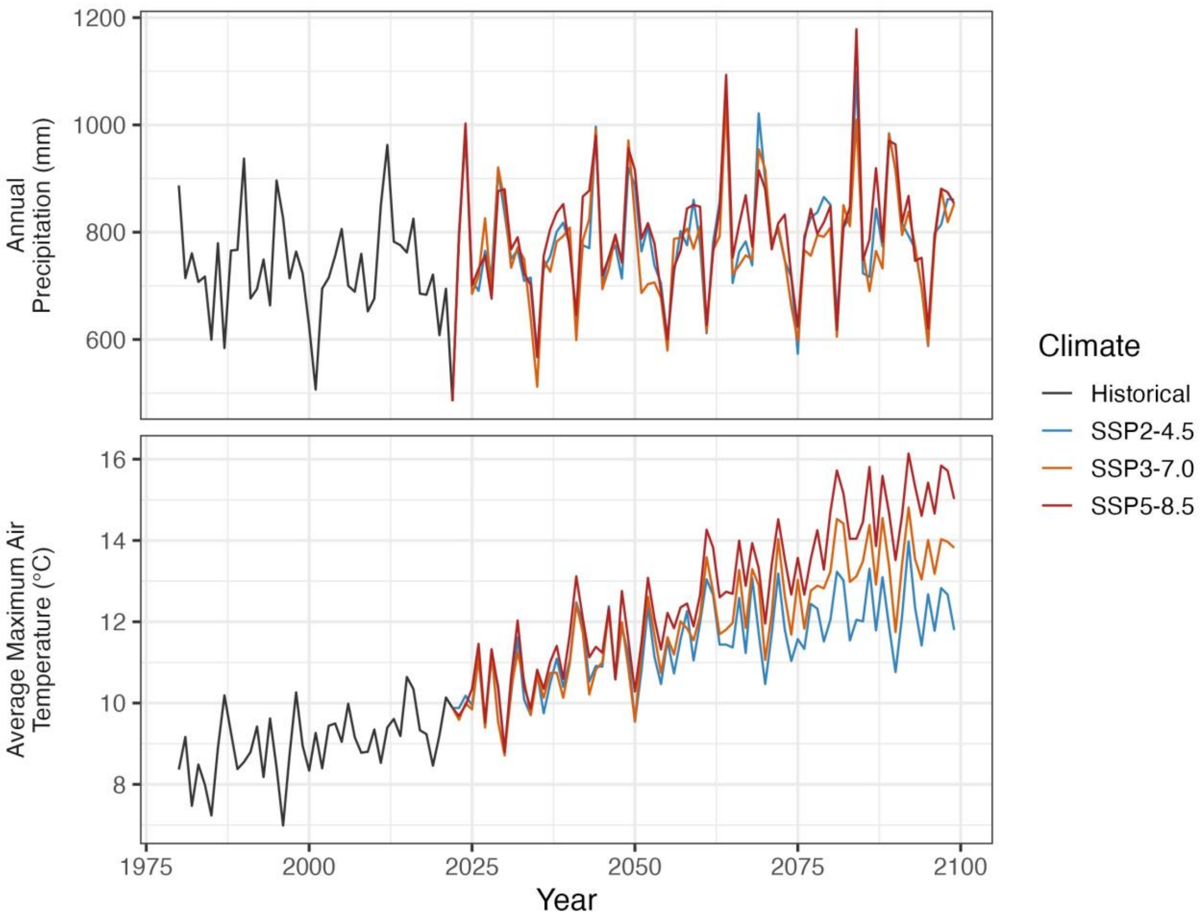


Figure 6. Annual precipitation (top) and maximum air temperature (bottom) for the Columbia Valley historical (black) and under the SSP2-4.5 (blue), SSP3-7.0 (orange), and SSP5-8.5 (red) climate change scenarios.

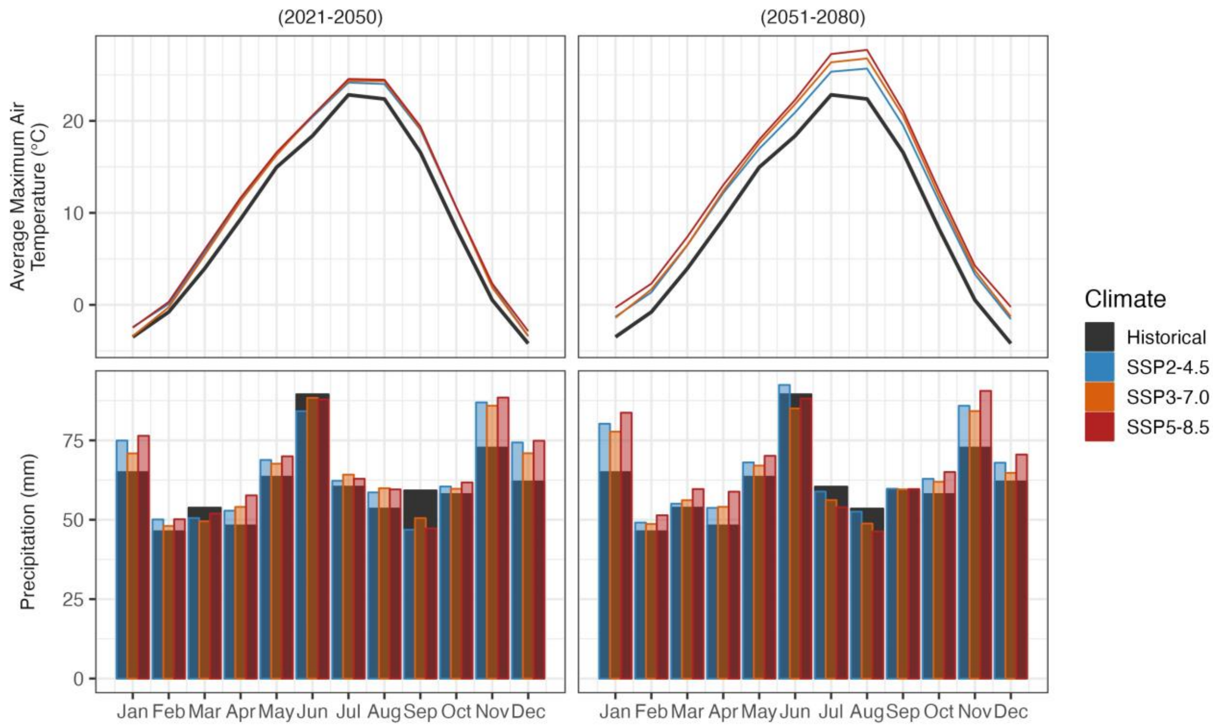


Figure 7. Average maximum monthly air temperature (top) and monthly precipitation (bottom) for the Columbia Valley historical (black) and under the SSP2-4.5 (blue), SSP3-7.0 (orange), and SSP5-8.5 (red) climate change scenarios.

4.3.2 Changes wetland conditions

Wetlands were treated as single points in the hydrological model to evaluate climate change at a high level. Results suggest there is likely to be greater increases in evaporation than in precipitation, especially during the later time period (**Error! Reference source not found.**). Loon Lake is further north and is cooler and wetter than Dogleg Lake, and Sun Creek is further south. Loon Lake experiences the smallest seasonal water deficit of the three points historically, and that trend continues into all the future projections, though it does increase (Table 4). Sun Creek is the only point that experiences a decrease in precipitation due to the effects of climate change in addition to increases in evapotranspiration, creating the greatest seasonal water deficits.

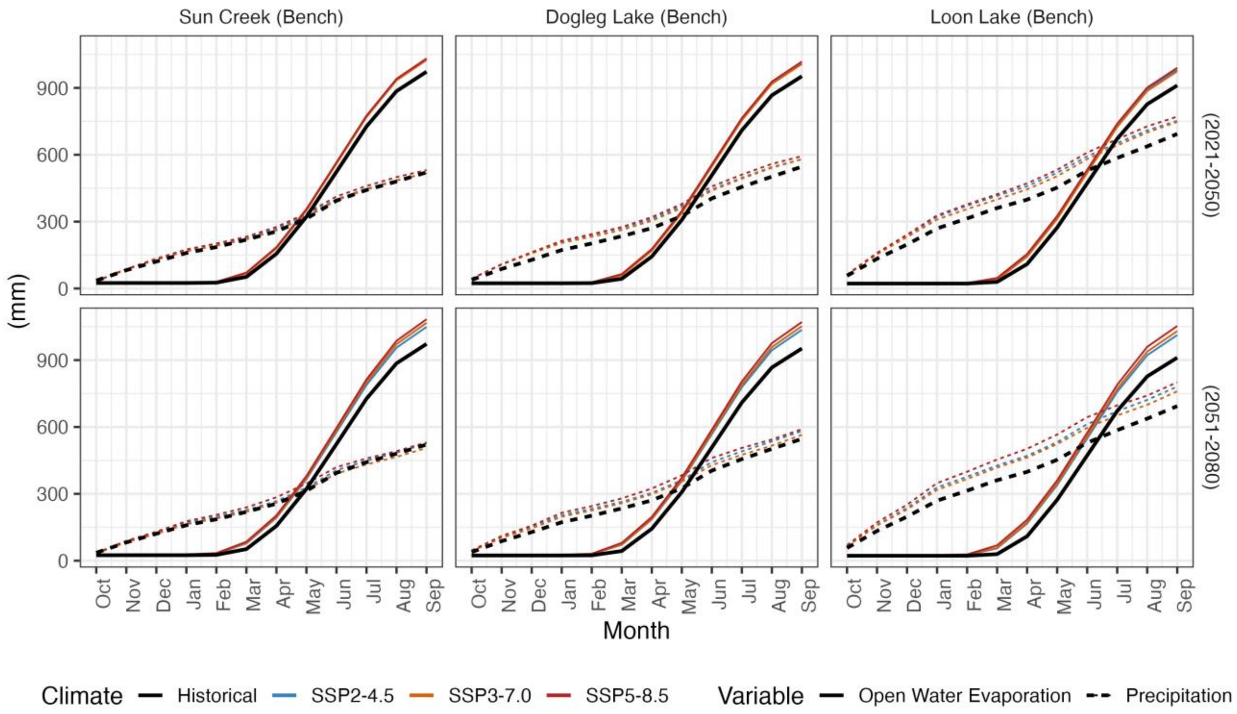


Figure 8. Open water evaporation (solid line) and precipitation (dashed line) for wetlands at Sun Creek (left), Dogleg Lake (middle), and Loon Lake (right) during two time periods.

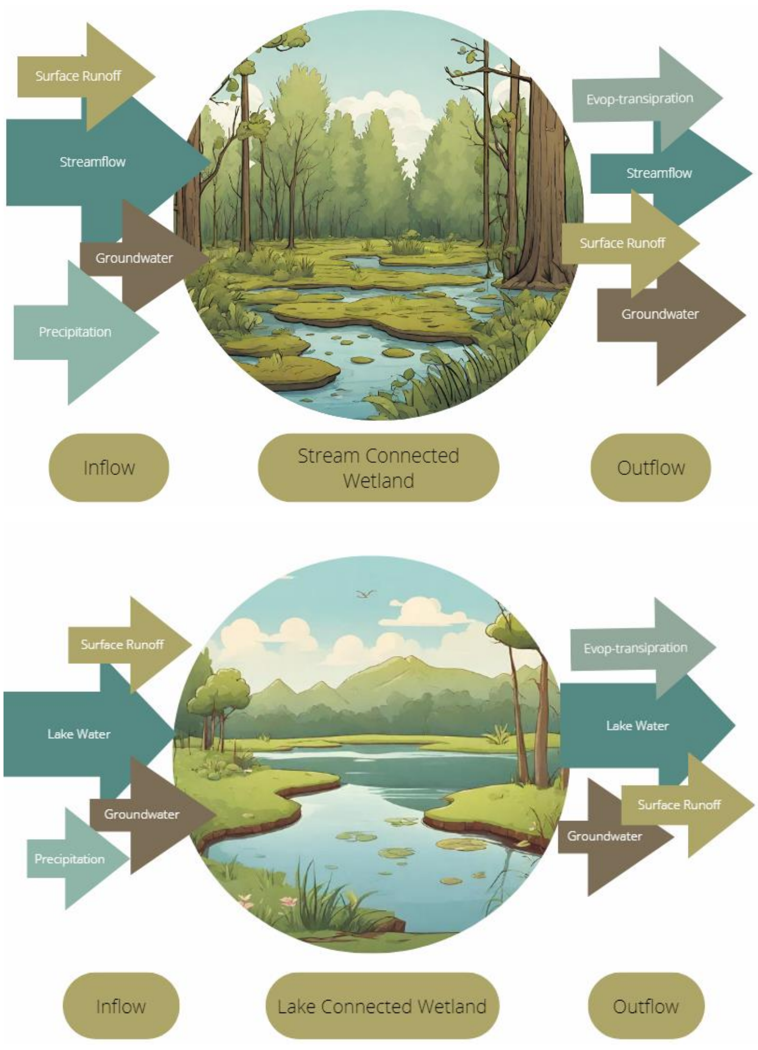
Table 4. Water balance metrics for point-sources at Loon Lake, Dogleg Lake, and Sun Creek.

Bench Water Balances				
Climate	Period	Open Water Evaporation (mm)	Precipitation (mm)	Change in storage dS (mm)
Dogleg Lake (Bench)				
Historical	(1991-2020)	952.4515	546.6352	-405.8163
SSP2-4.5	(2021-2050)	1008.8378	579.8746	-428.9633
SSP3-7.0	(2021-2050)	1007.2892	580.1713	-427.1179
SSP5-8.5	(2021-2050)	1018.0273	593.7734	-424.2539
SSP2-4.5	(2051-2080)	1035.9122	582.0631	-453.8491
SSP3-7.0	(2051-2080)	1052.3778	564.5370	-487.8407
SSP5-8.5	(2051-2080)	1070.9644	590.1594	-480.8050
Loon Lake (Bench)				
Historical	(1991-2020)	911.1030	693.6272	-217.4758
SSP2-4.5	(2021-2050)	980.8914	752.3648	-228.5265
SSP3-7.0	(2021-2050)	974.4148	747.5907	-226.8241
SSP5-8.5	(2021-2050)	990.1448	770.8392	-219.3056
SSP2-4.5	(2051-2080)	1012.3241	781.0384	-231.2857
SSP3-7.0	(2051-2080)	1030.3818	760.0017	-270.3802
SSP5-8.5	(2051-2080)	1053.1426	800.4779	-252.6648
Sun Creek (Bench)				
Historical	(1991-2020)	972.6675	521.1684	-451.4991
SSP2-4.5	(2021-2050)	1025.2586	517.6235	-507.6351
SSP3-7.0	(2021-2050)	1025.2861	517.8324	-507.4537
SSP5-8.5	(2021-2050)	1032.0288	531.2125	-500.8163
SSP2-4.5	(2051-2080)	1048.9891	525.4740	-523.5151
SSP3-7.0	(2051-2080)	1067.3215	505.7319	-561.5896
SSP5-8.5	(2051-2080)	1083.1861	530.8411	-552.3450

5 Discussion

5.1 Wetland Vulnerability

The bench wetlands in the Upper Columbia Valley can either exist in isolation or connected to a waterbody, including lakes, streams, or both. The water budget for each of these is different, where the relative contributions of stream/lake water, groundwater, precipitation, and surface runoff vary (Figure 9). Isolated wetlands rely more heavily on storms bringing precipitation and surface runoff, as well as groundwater influences, whereas connected wetlands can have much more reliable, steady inflow through a nearby stream. Lake levels tend to change more slowly than stream levels, and do not exhibit the same magnitude of change.



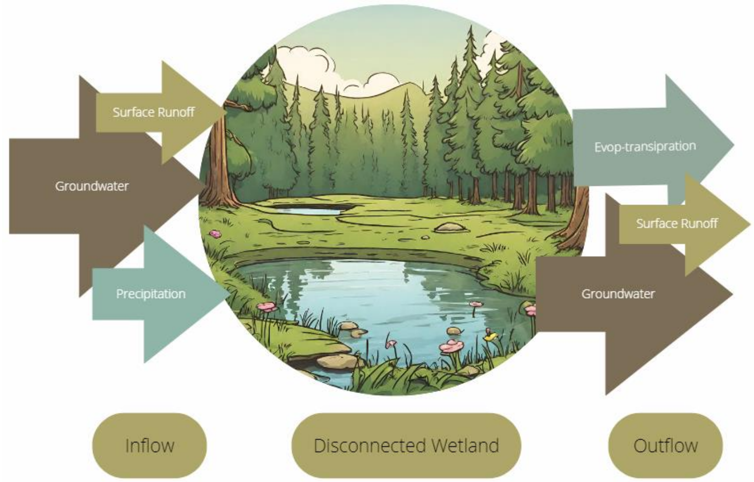


Figure 9. A conceptual diagram illustrating the relative contributions of inflow and outflow to the annual water balances of a stream connected wetland (top), lake connected wetland (middle), and disconnected wetland (bottom).

Connectivity and climatic conditions appear to be primary drivers in the vulnerability of the bench wetlands. Roughly 10% of the mapped bench wetlands within the Upper Columbia Valley were found to be vulnerable to the effects of climate change. The majority of wetlands within the study area are connected to a water body, and over half of the disconnected wetlands were found to be vulnerable. Most wetlands, including vulnerable wetlands, occur in the northern region of the study area. There were only two vulnerable wetlands in found in the central region and none in the southern region, and there were no disconnected but non-vulnerable wetlands in the southern region, illustrating the important of connectivity in maintaining wetland resilience. Anecdotal evidence suggests that disconnected and vulnerable wetlands have already dried up in the southern portion of the study area.

Looking at the water budget components from north to south, there is a clear climatic influence with warmer, drier air temperatures in the south driving greater seasonal water deficits than we see in the north. Climate scenarios show increases in seasonal deficits across the bench but with greater disparity between precipitation and evaporation occurring in the southern regions, particularly as precipitation decreases in some scenarios. This further supports the need for stream or lake influences to maintain wetlands as the seasonal water deficit increases across the study area.

Other studies have found similar results, illustrating the vulnerability of small wetlands to the effects of climate change in the southern interior of British Columbia (Bunnell et al., 2010). As depth is loosely related to surface area, smaller wetlands may experience even greater water loss due to increased evaporation (Bunnell et al., 2010). As most of the wetlands within our study area are less than a hectare in area, it is imperative that action be taken now to prevent further losses and to improve conditions for existing wetlands to build climate resilience.

5.2 Recommendations

Due to the strong links in connectivity and climate condition on the success of bench wetlands in the Upper Columbia Valley, our recommendations are to:

- Explore the disconnected wetlands in the central zone and determine if and how reliable the groundwater influence is supporting these and ensure there are no potential future risks to this source;
- While there is historic evidence of beaver activity in the region, either disturbance or climatic conditions altering the landscape have reduced beaver activity along the bench, and building beaver dam analogs may create the same effect and increase wetland resilience;
- For restoration efforts, focus on wetlands that are or could be connected to a surface water source;
- Do not attempt to restore or create wetlands where there is no waterbody connection, particularly in the southern region, as this is unlikely to work in the long-term

6 Closing

The Upper Columbia River bench wetlands are experiencing climatic pressures and many are vulnerable to the effects of ongoing climate change. Connectivity to a water body such as a stream or lake help reduce vulnerability and are extremely important in maintaining wetlands in the southern and central regions of the study area that experience greater evaporation and less precipitation; this will continue to be important as climate changes increases the seasonal water deficit across the study area but particularly in the southern zone.

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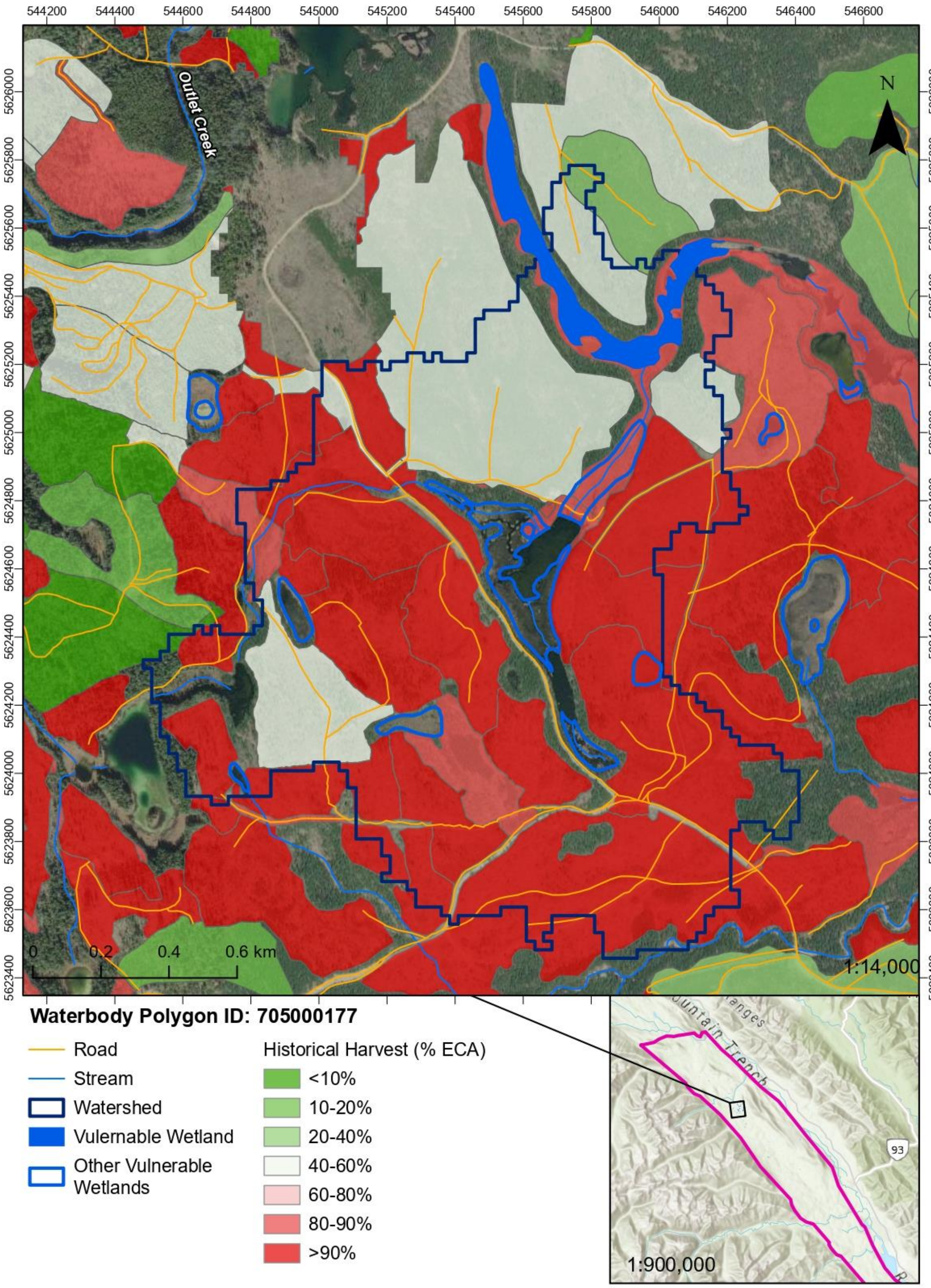
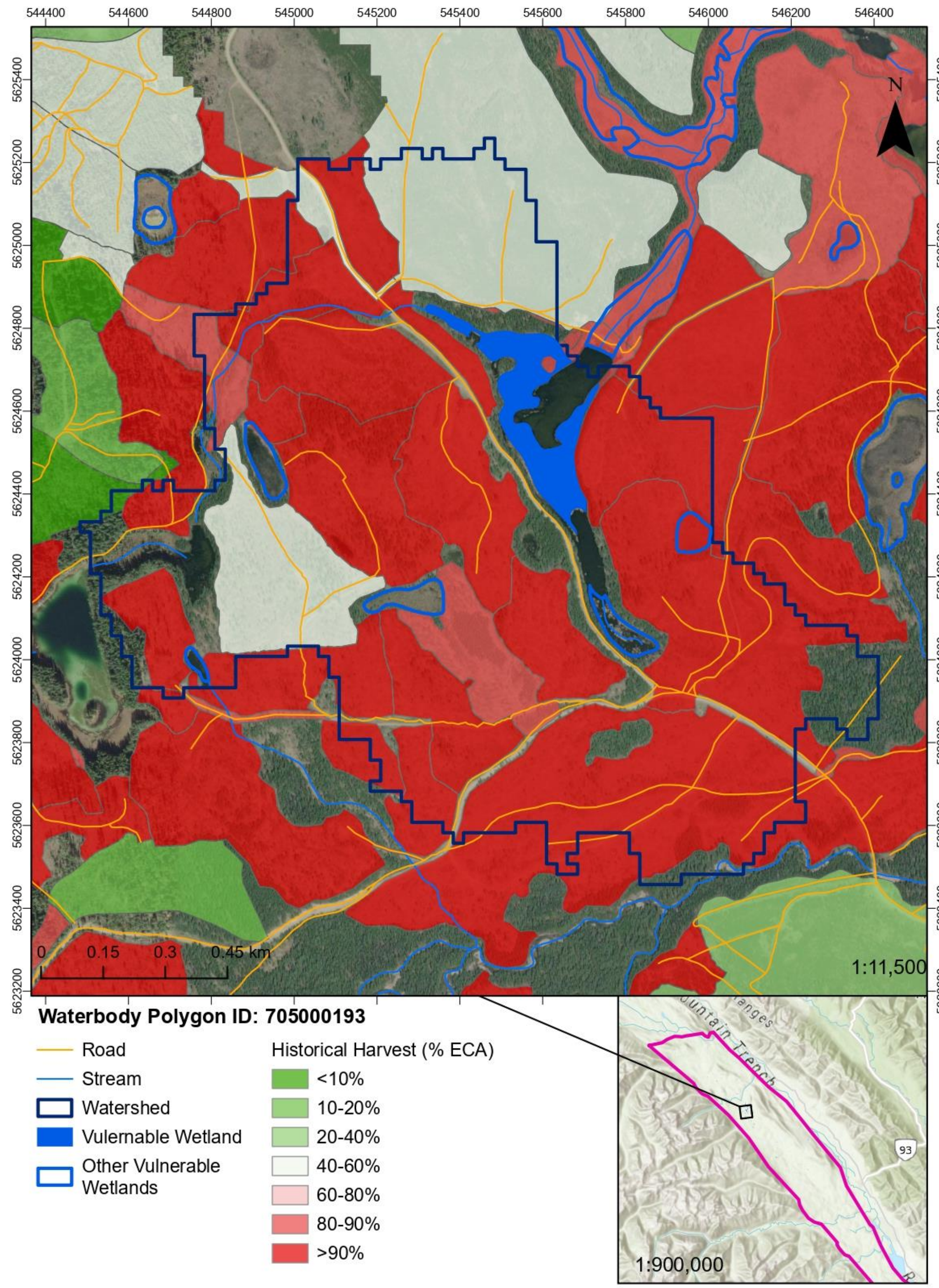
8 Appendices

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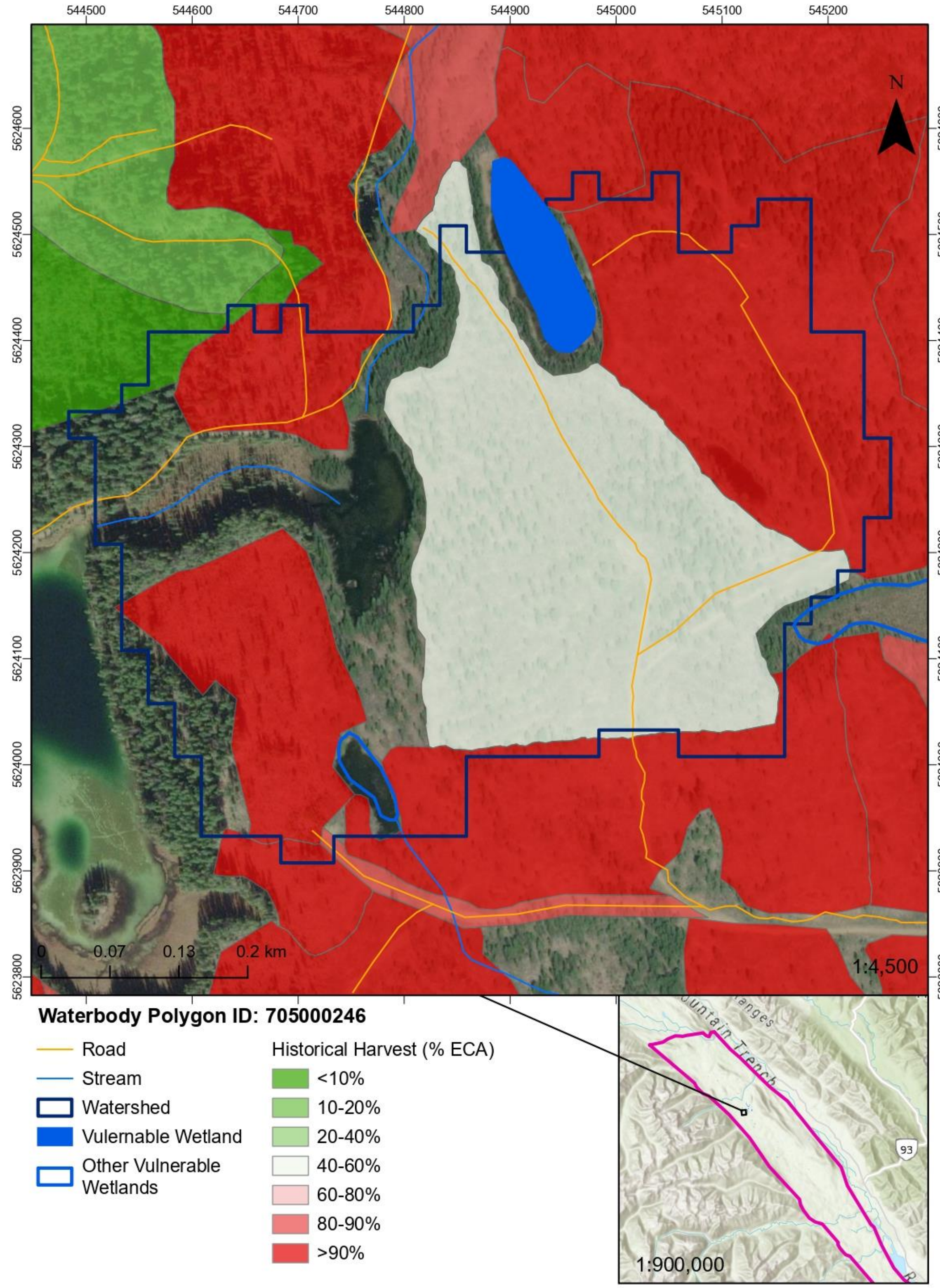
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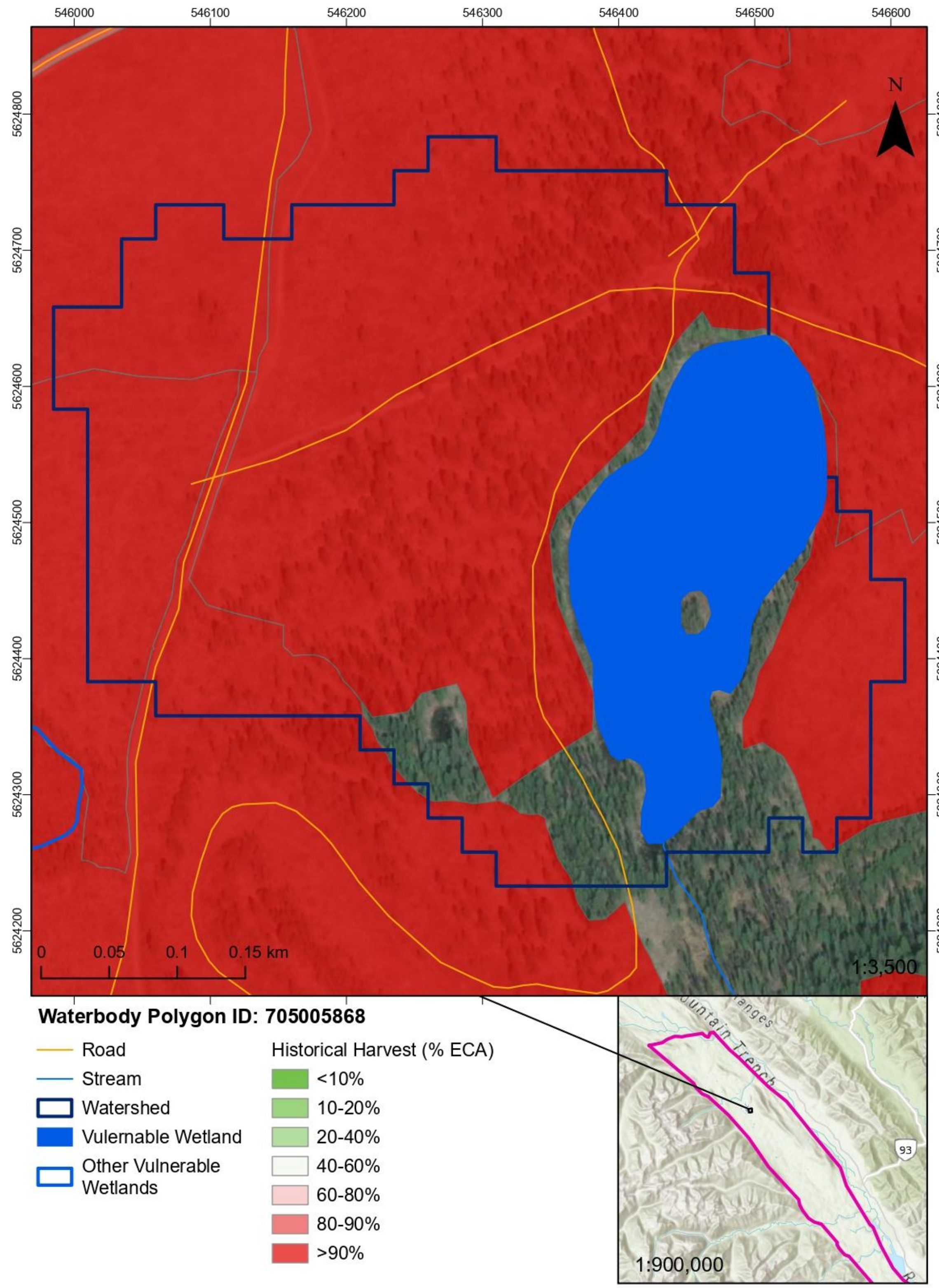

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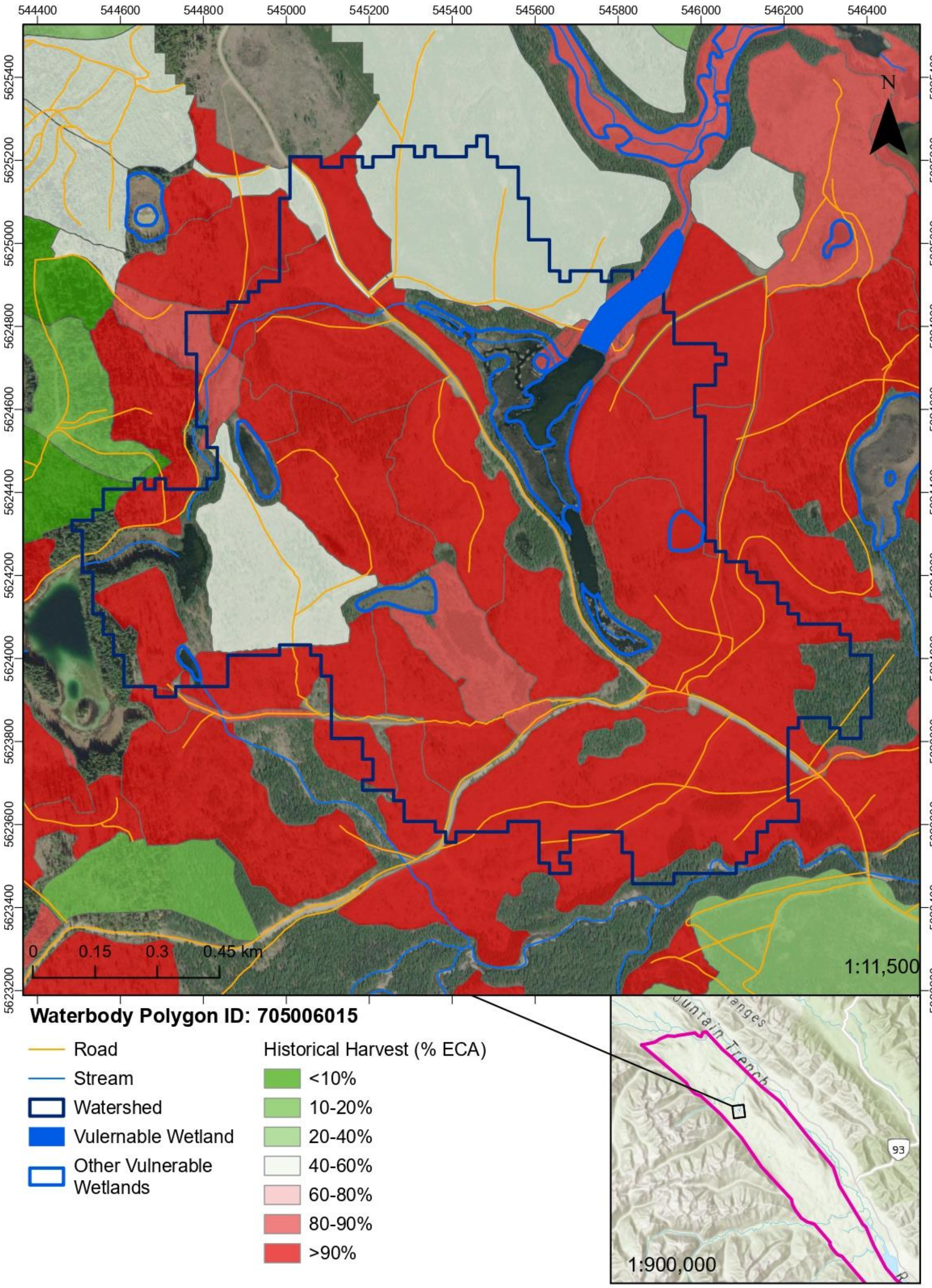
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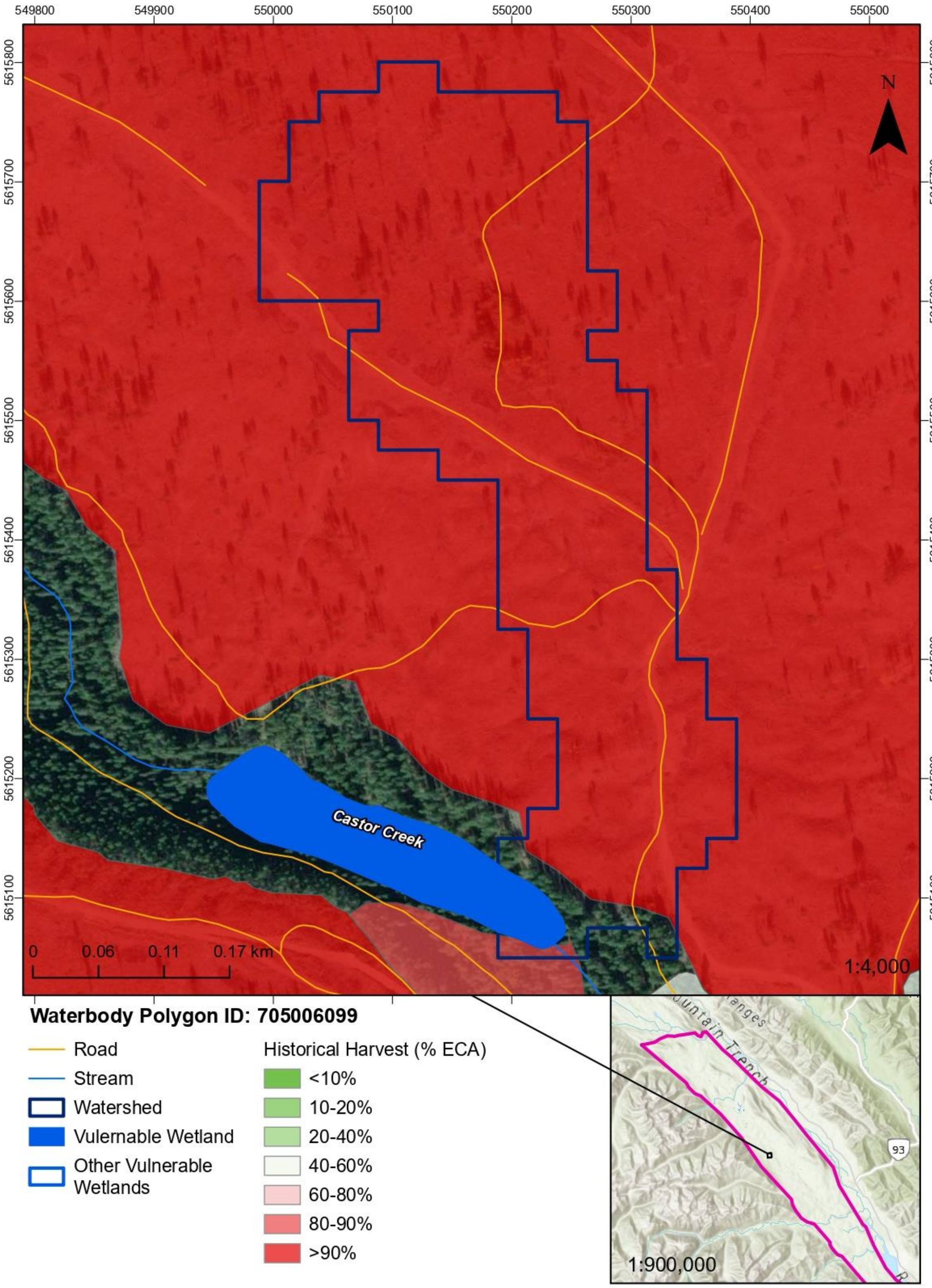
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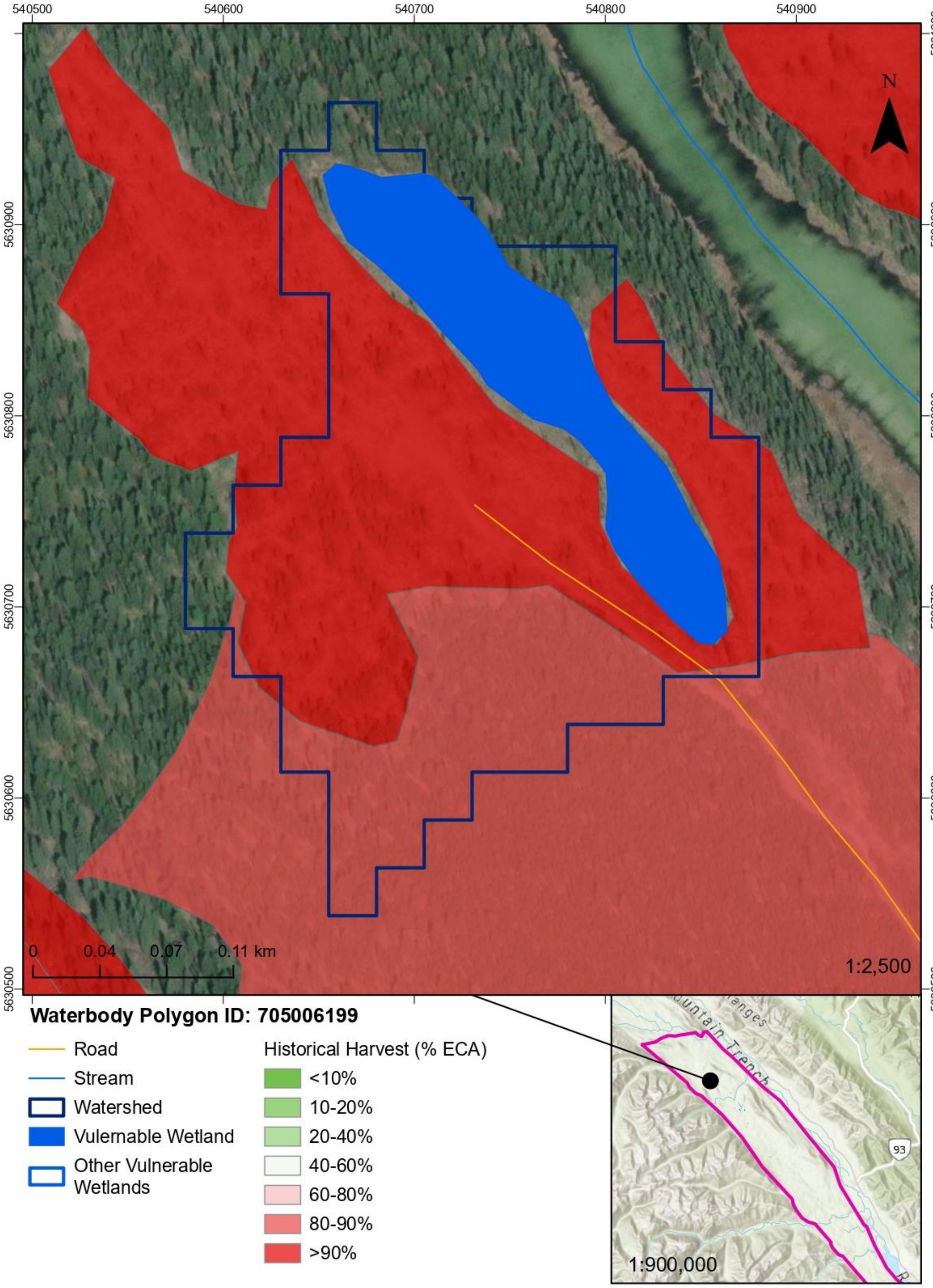

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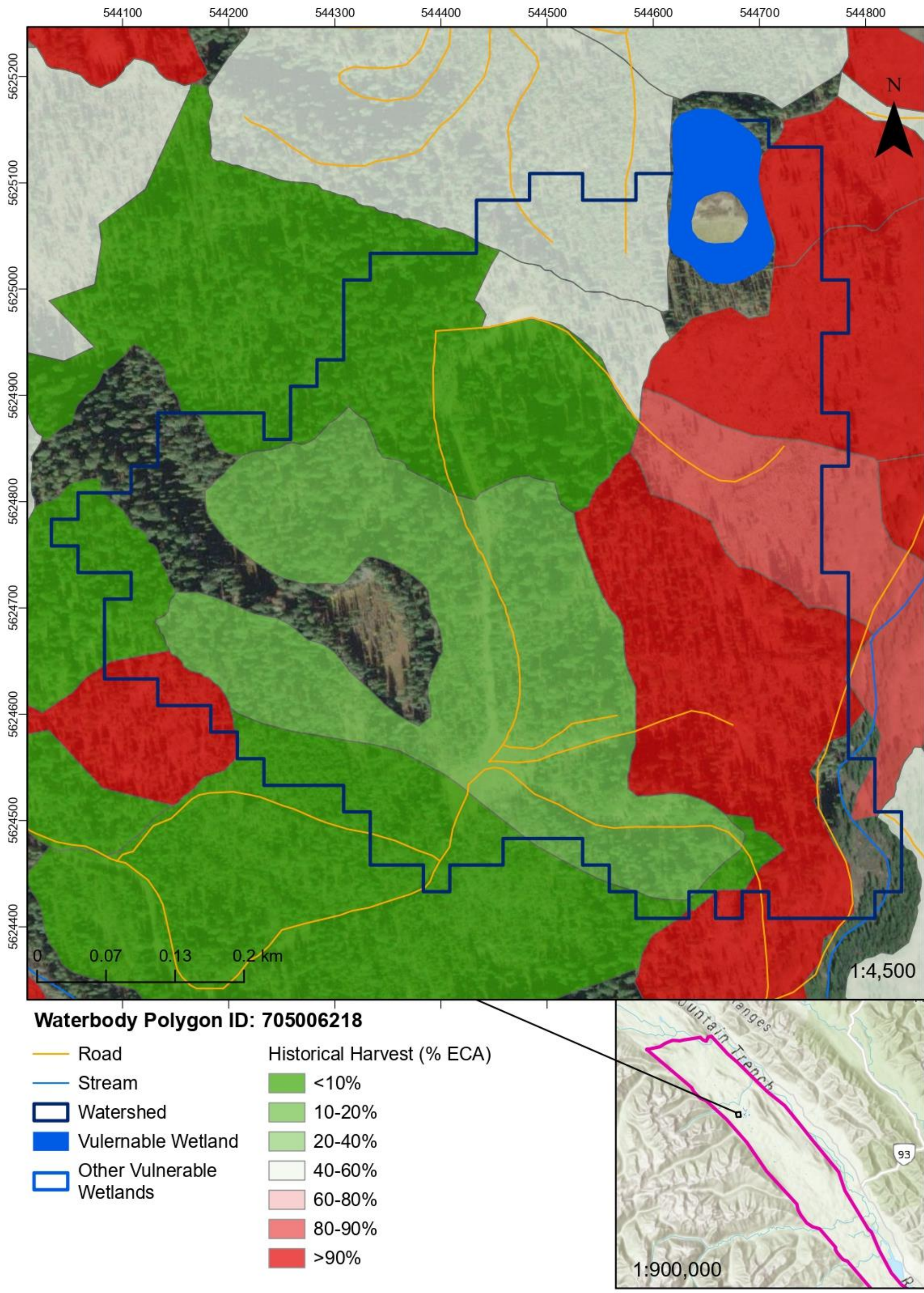

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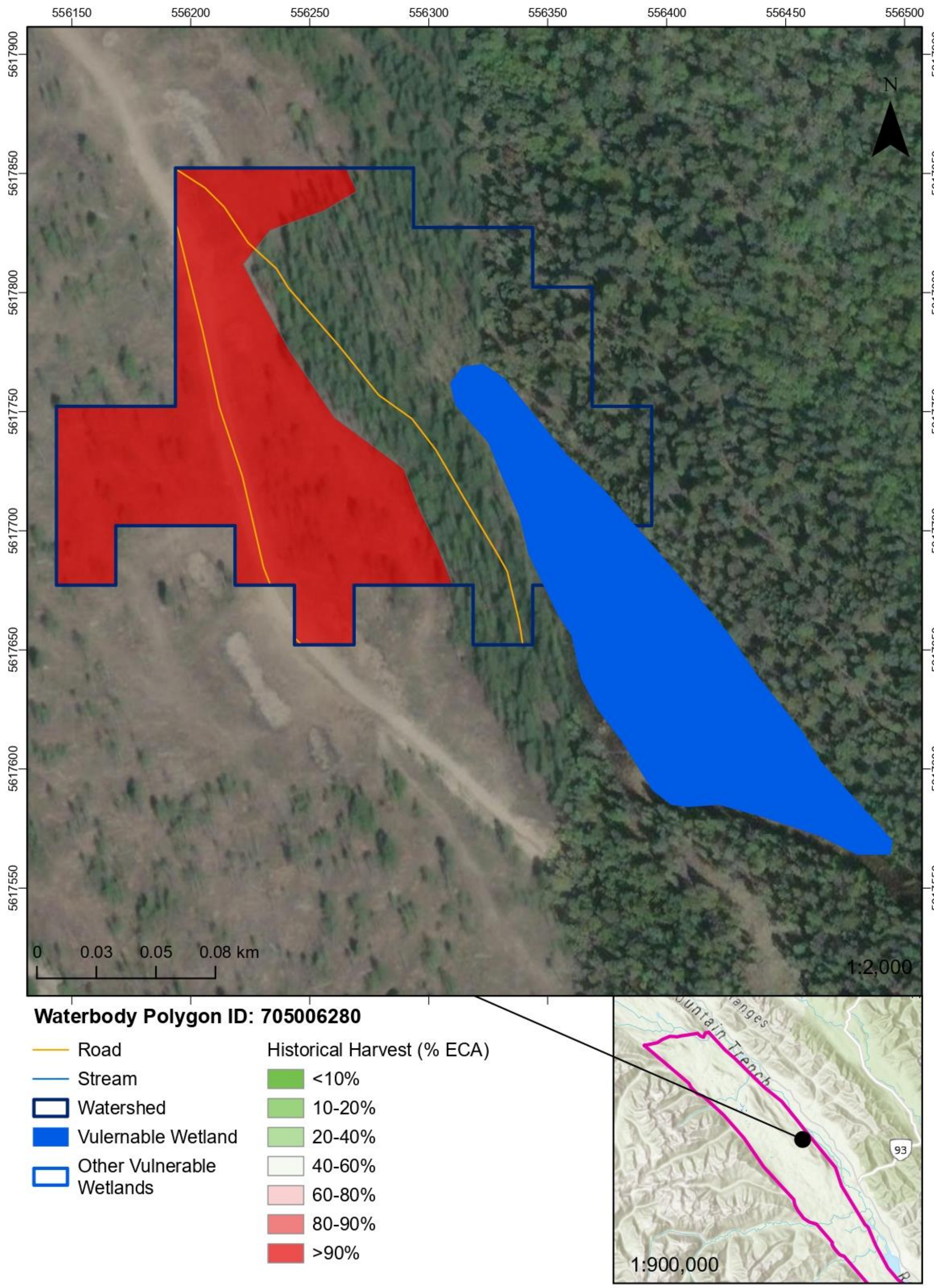

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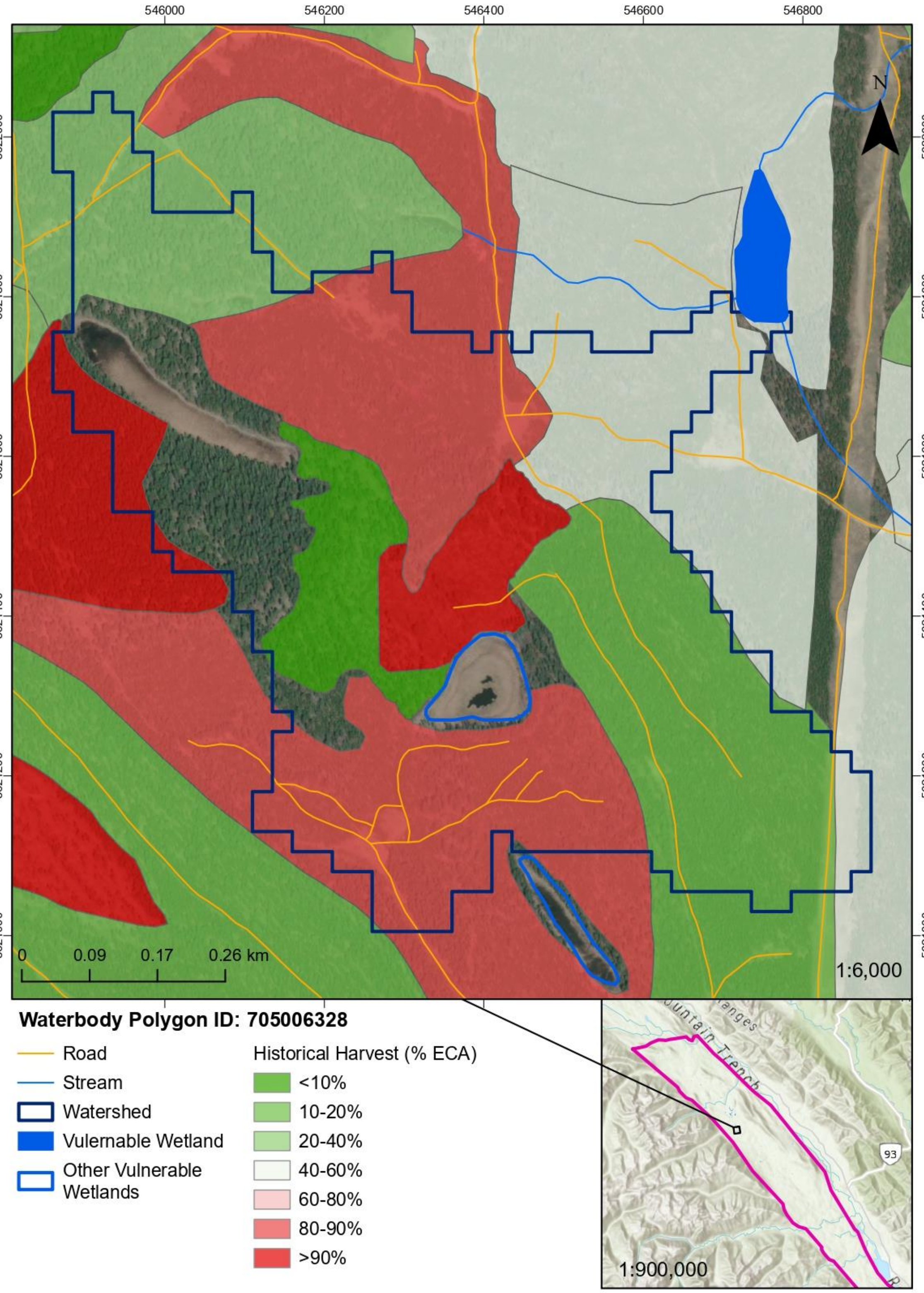
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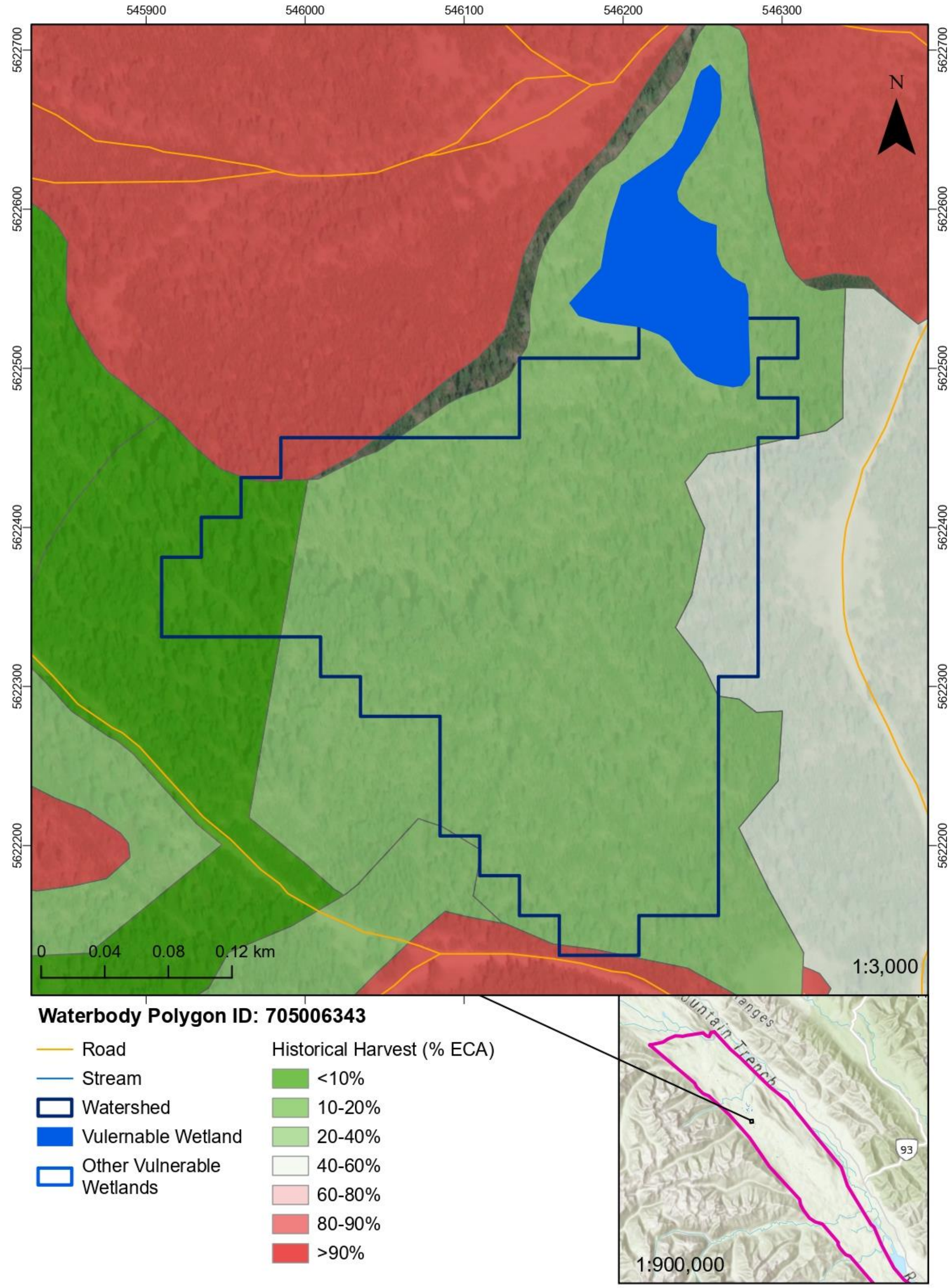
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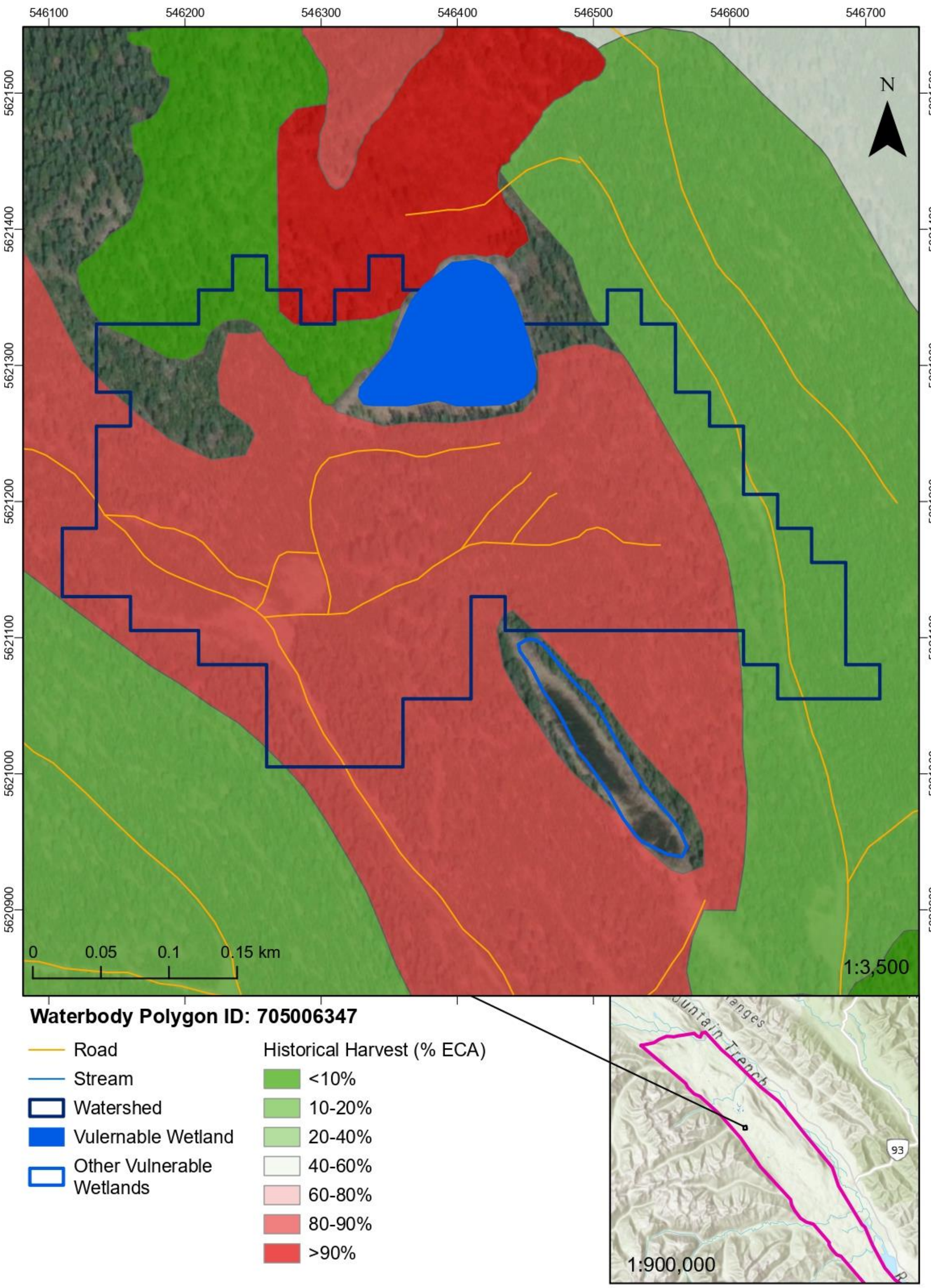
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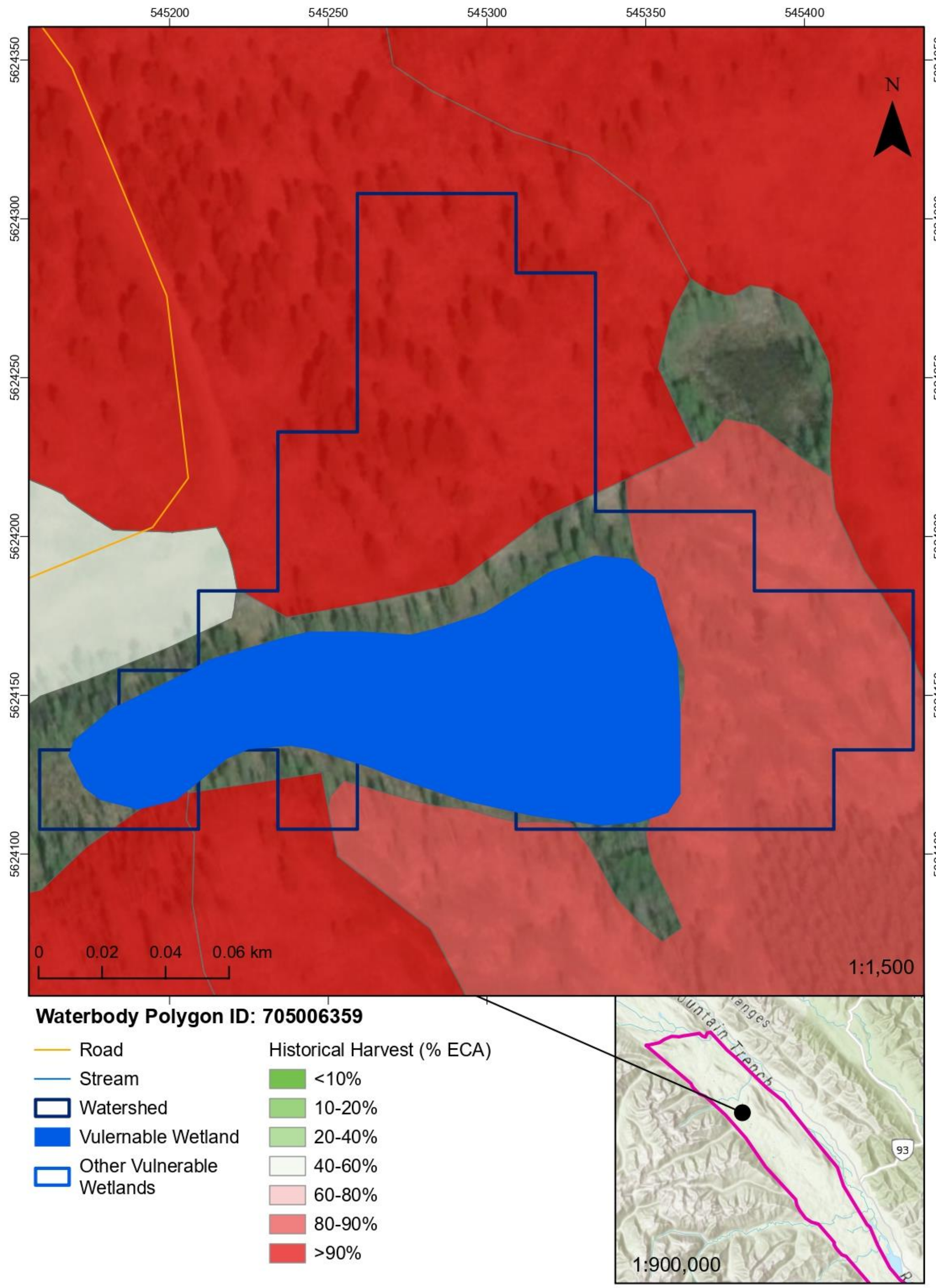
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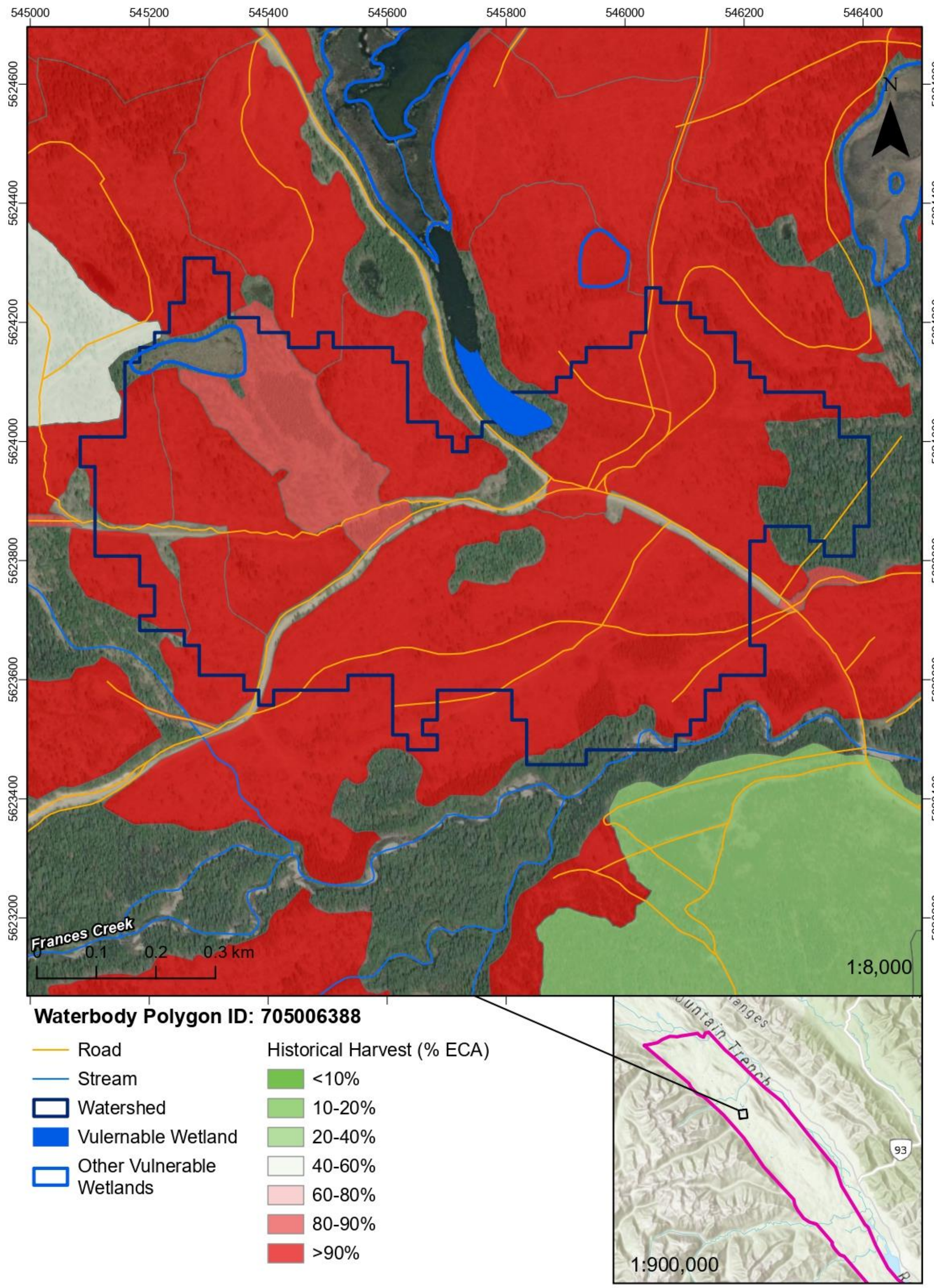
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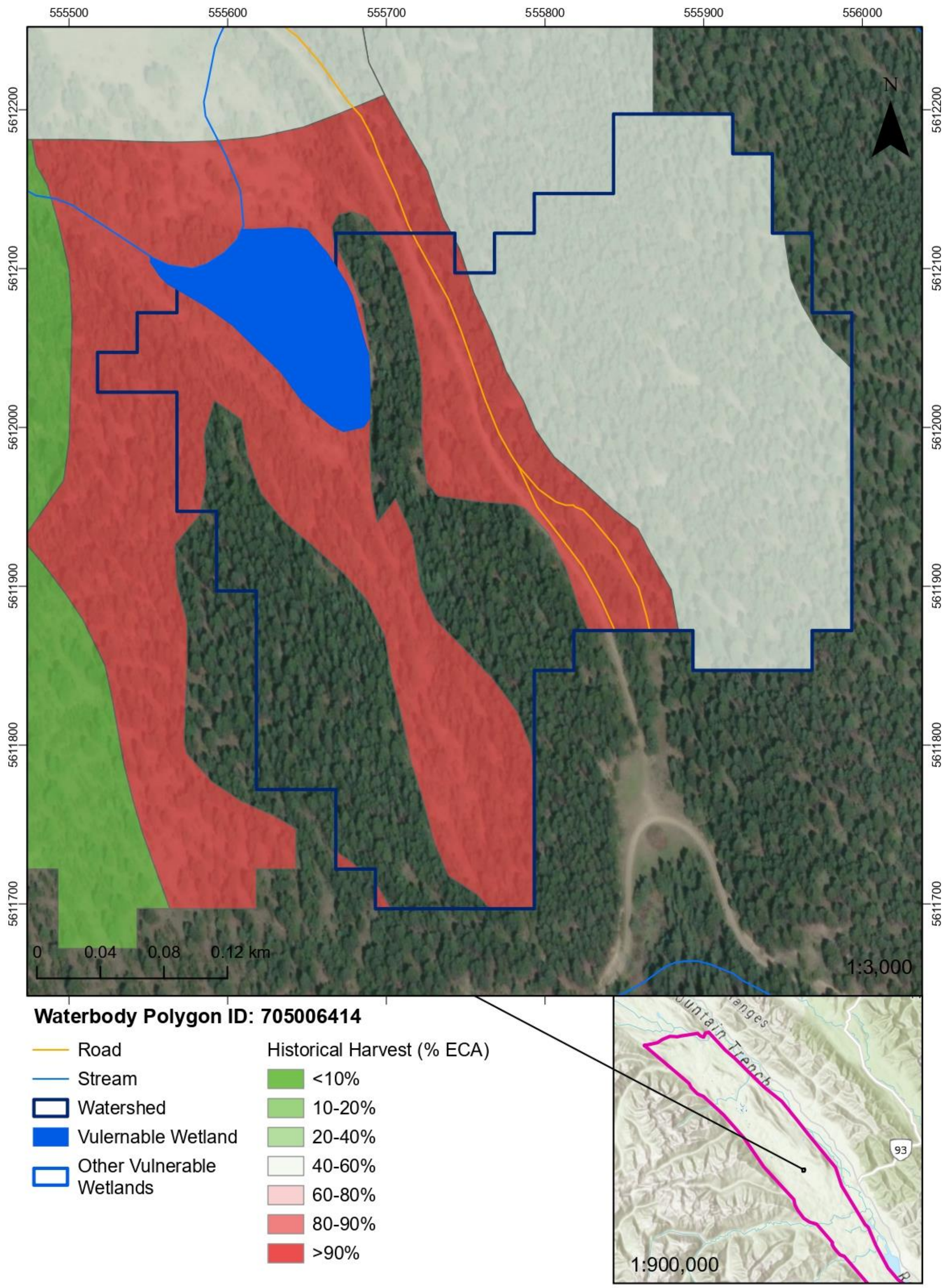
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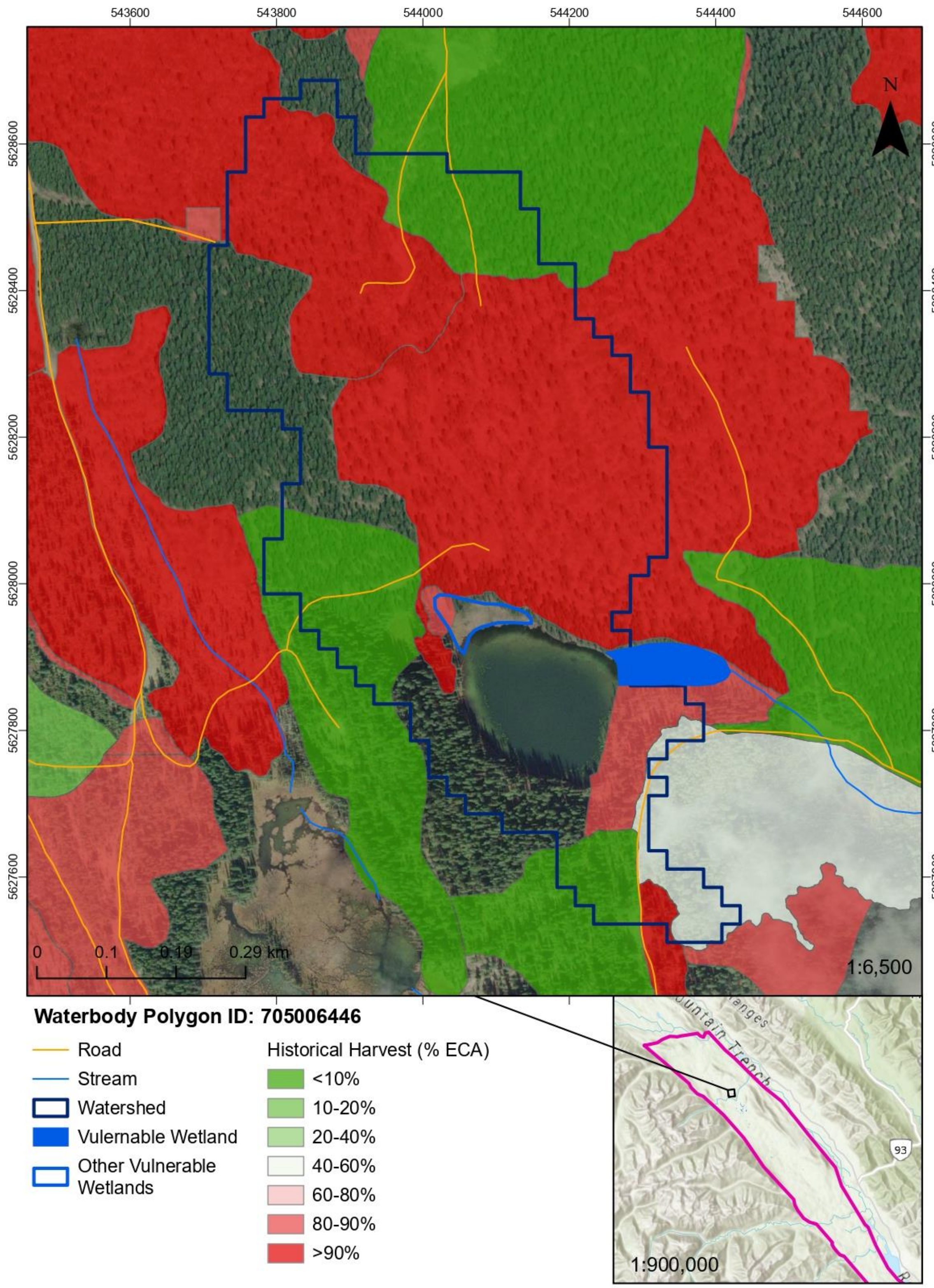
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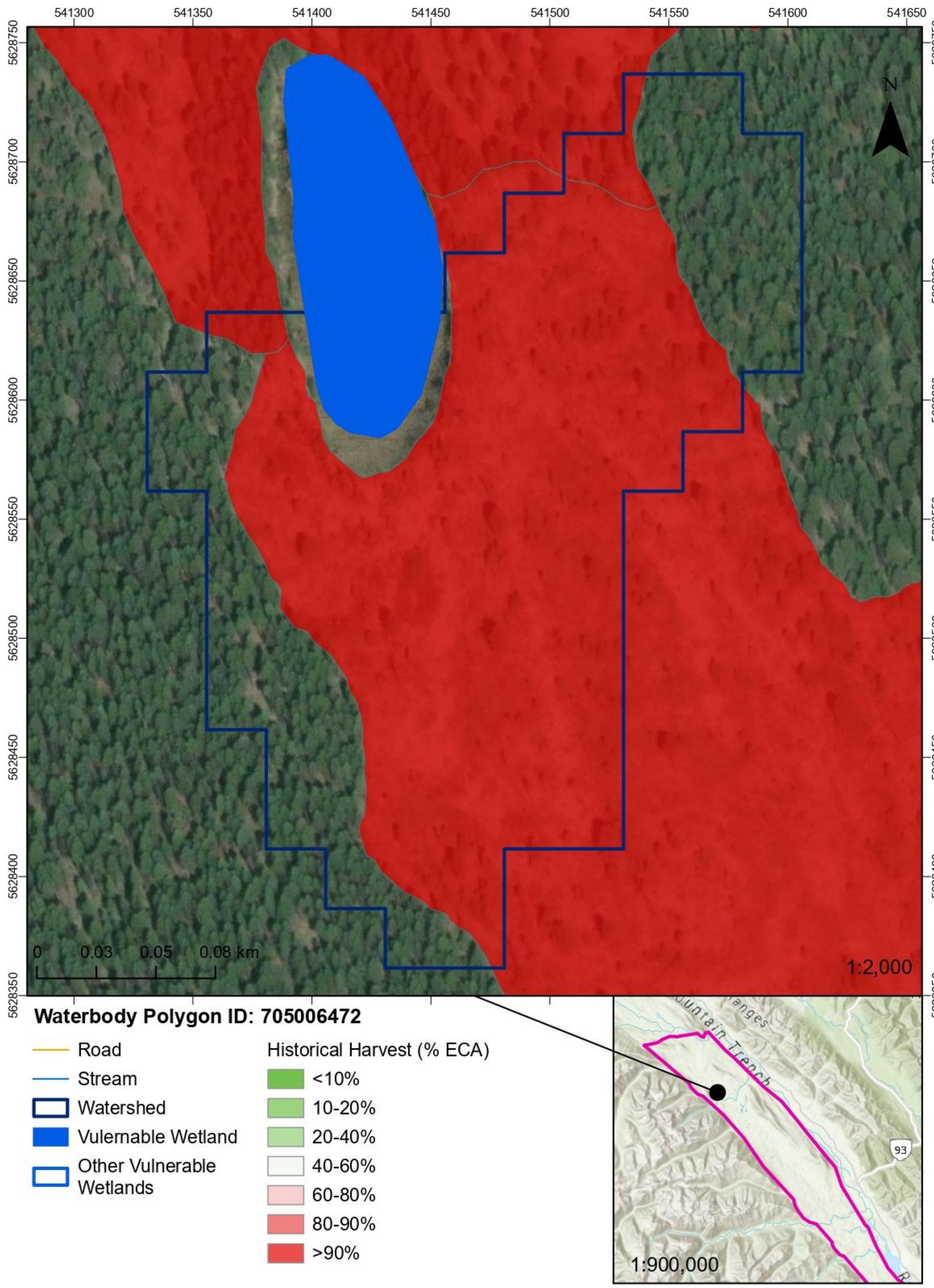
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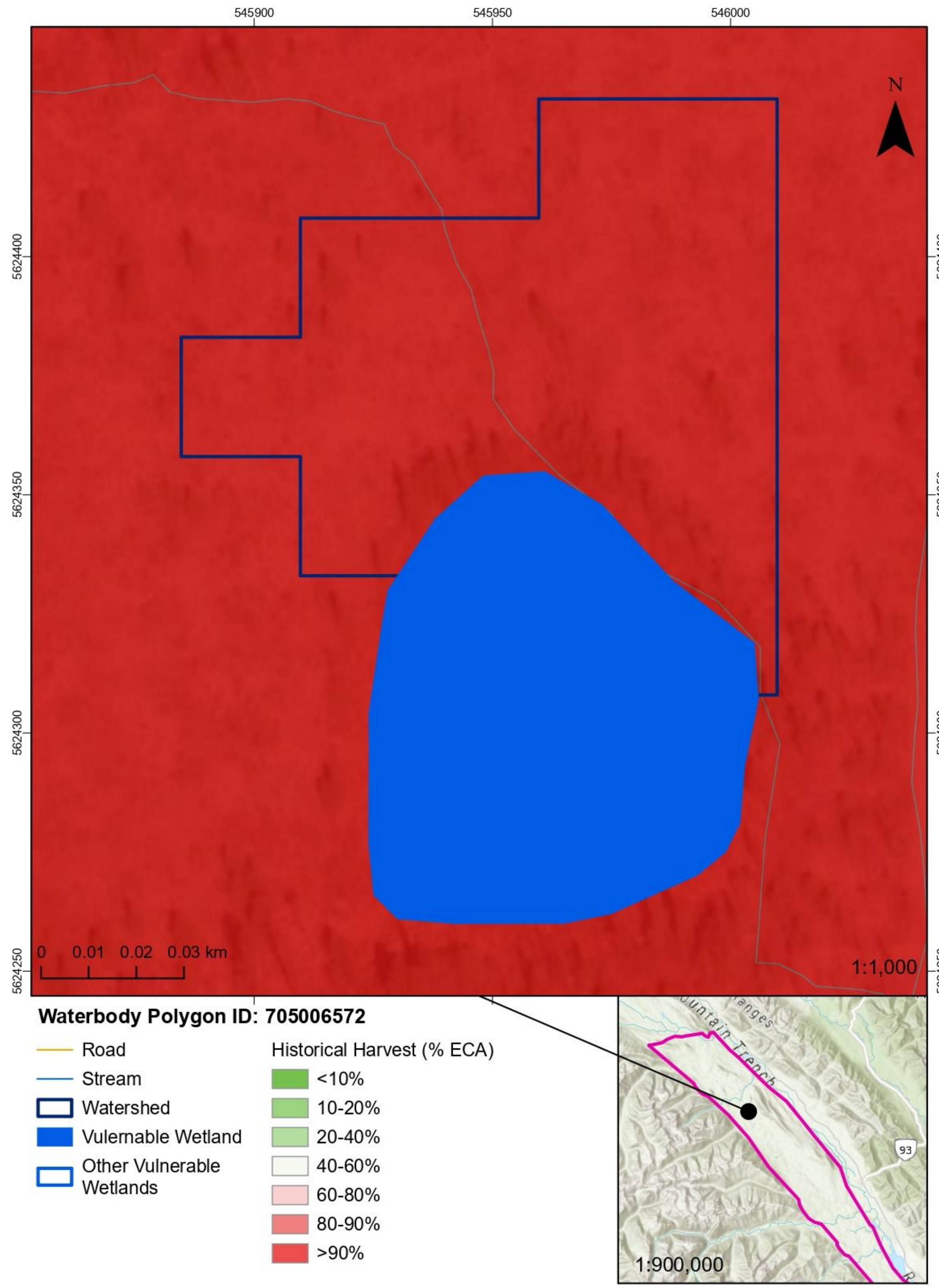
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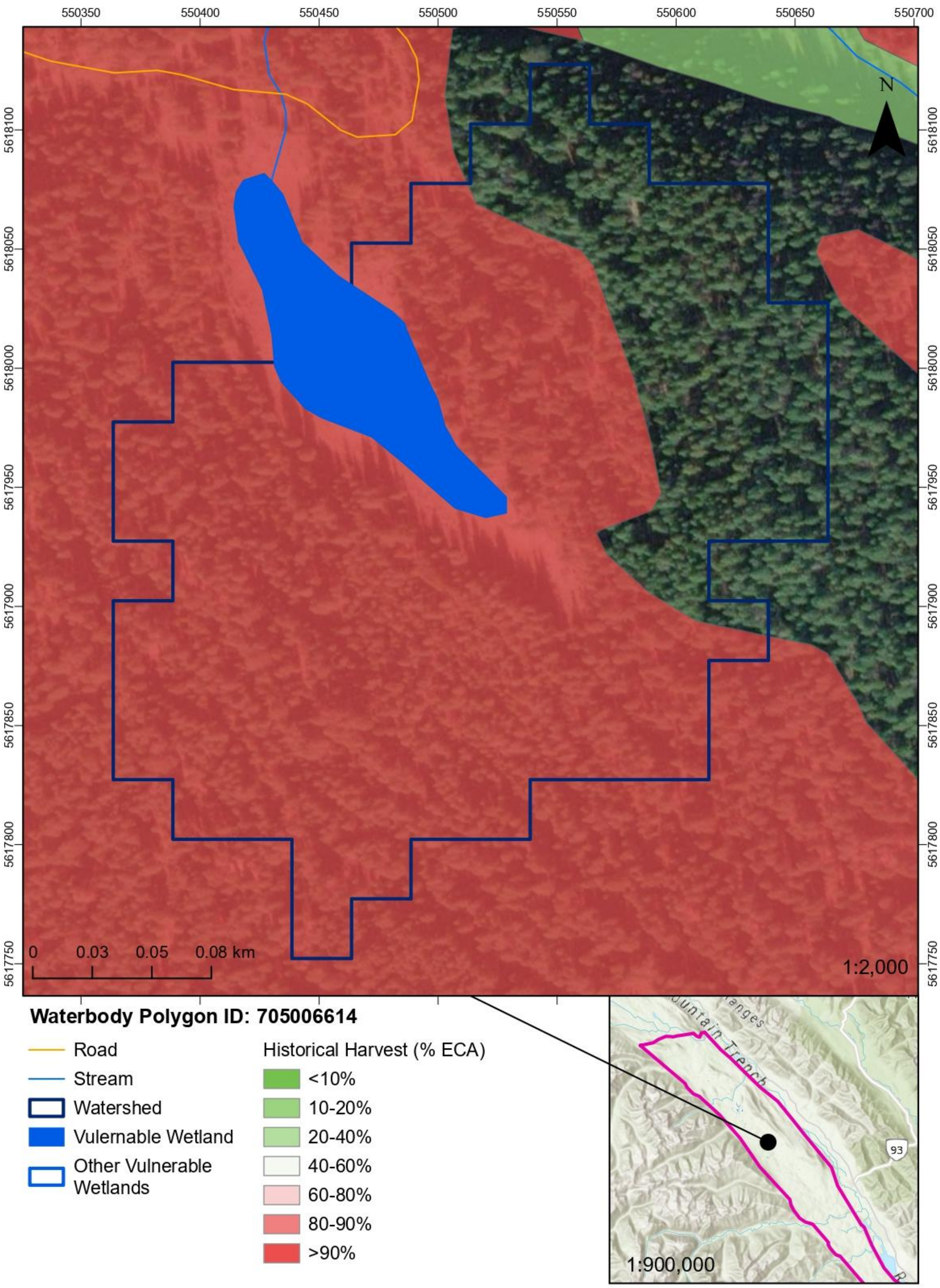

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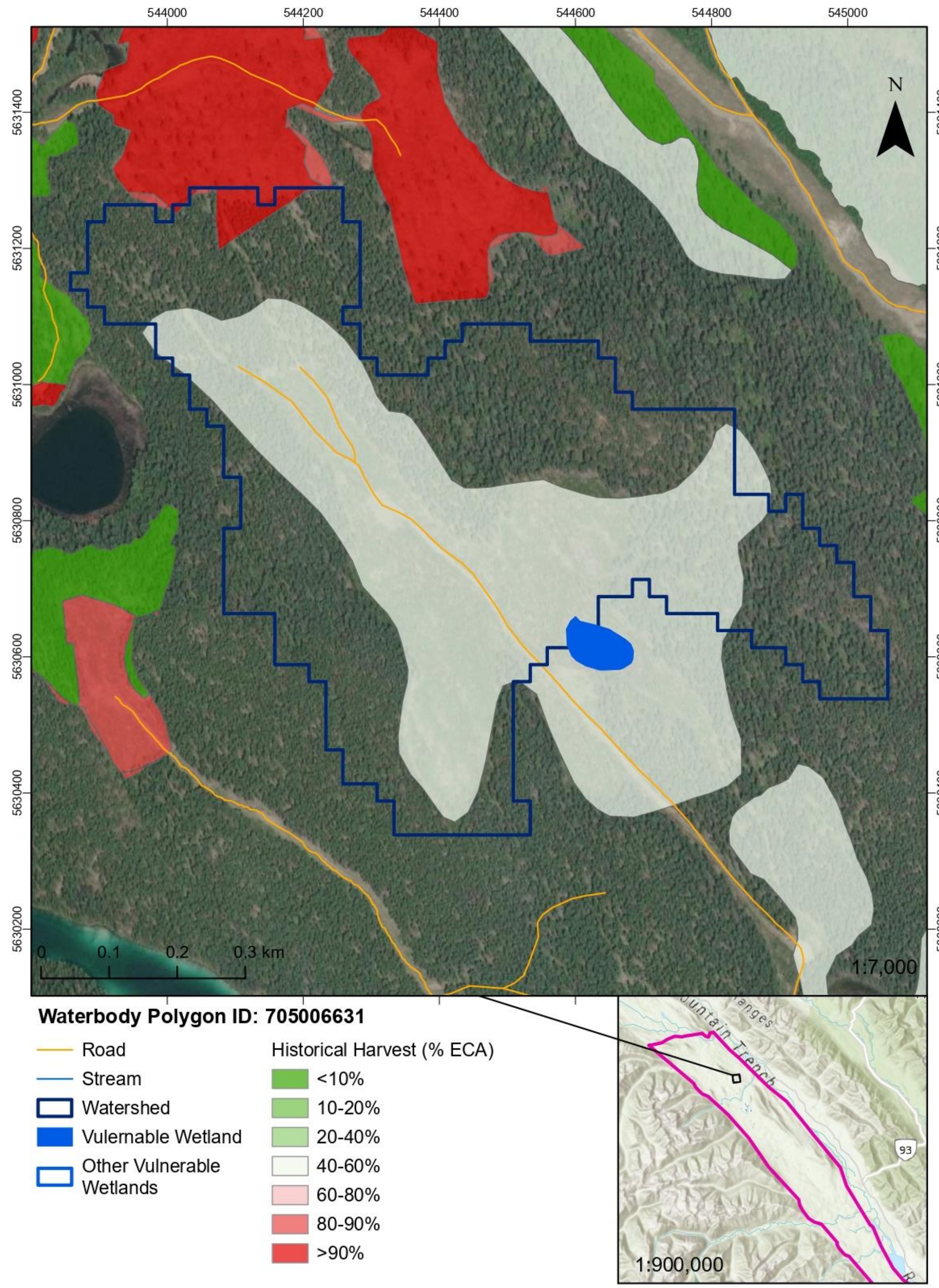

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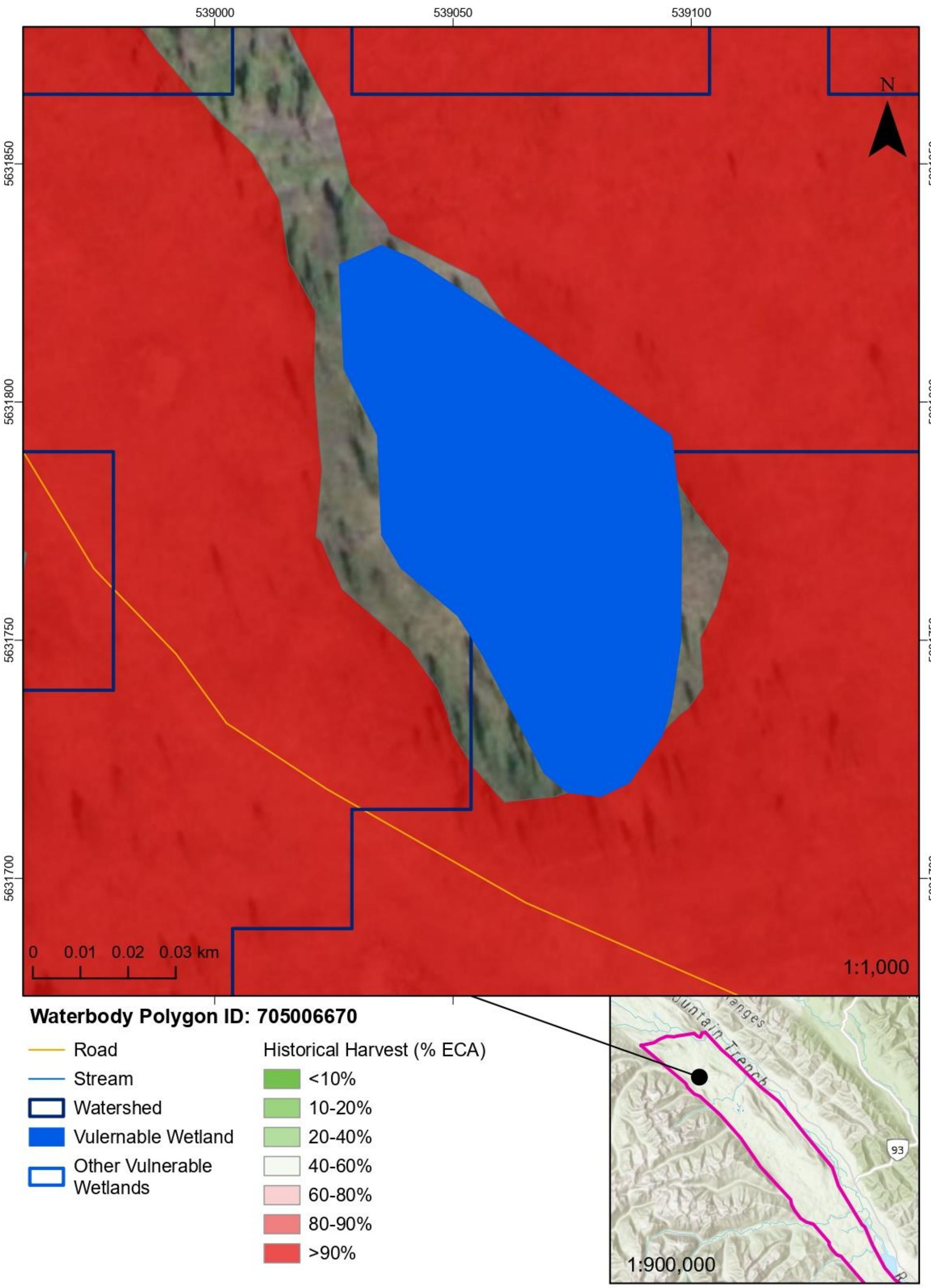
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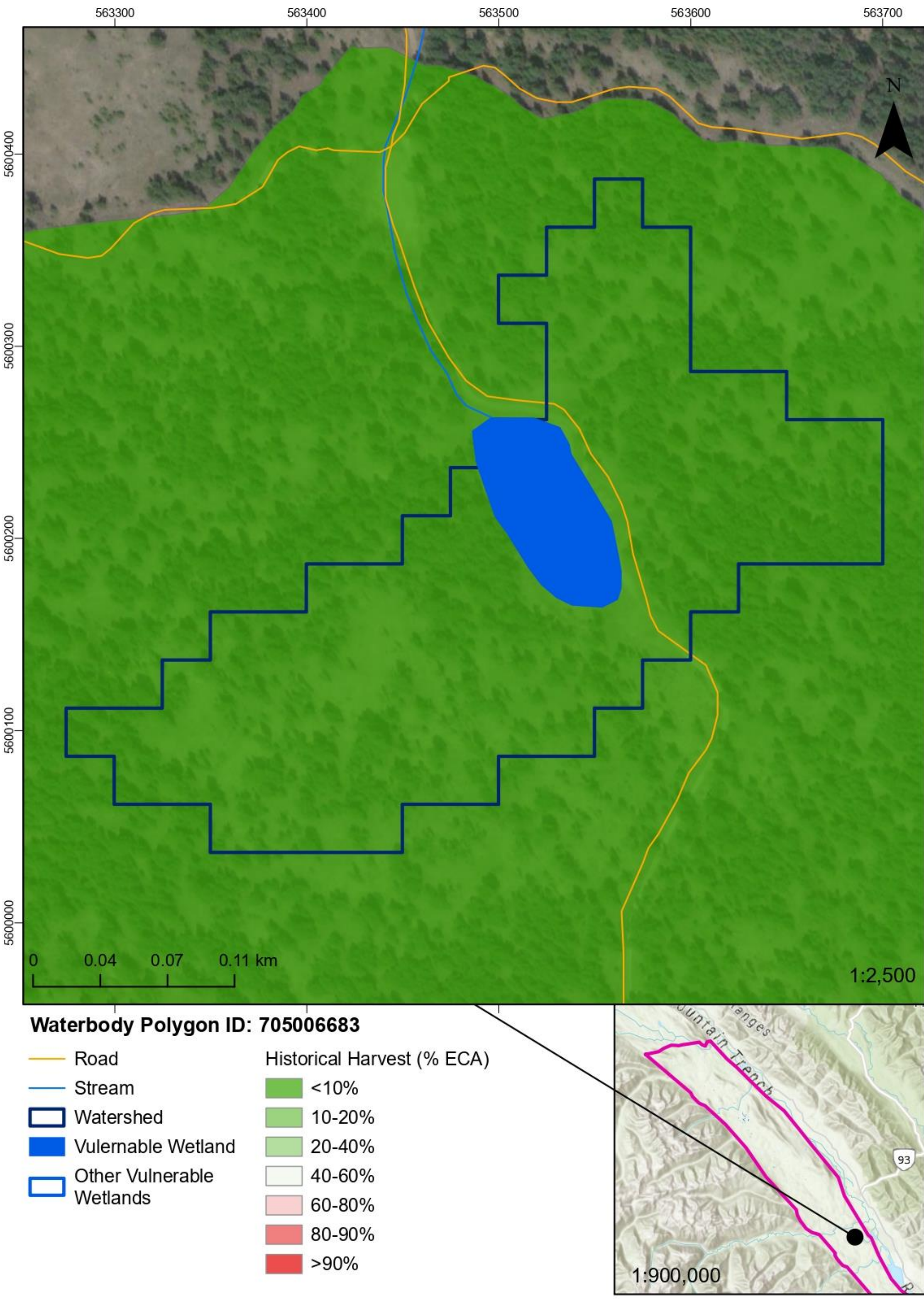
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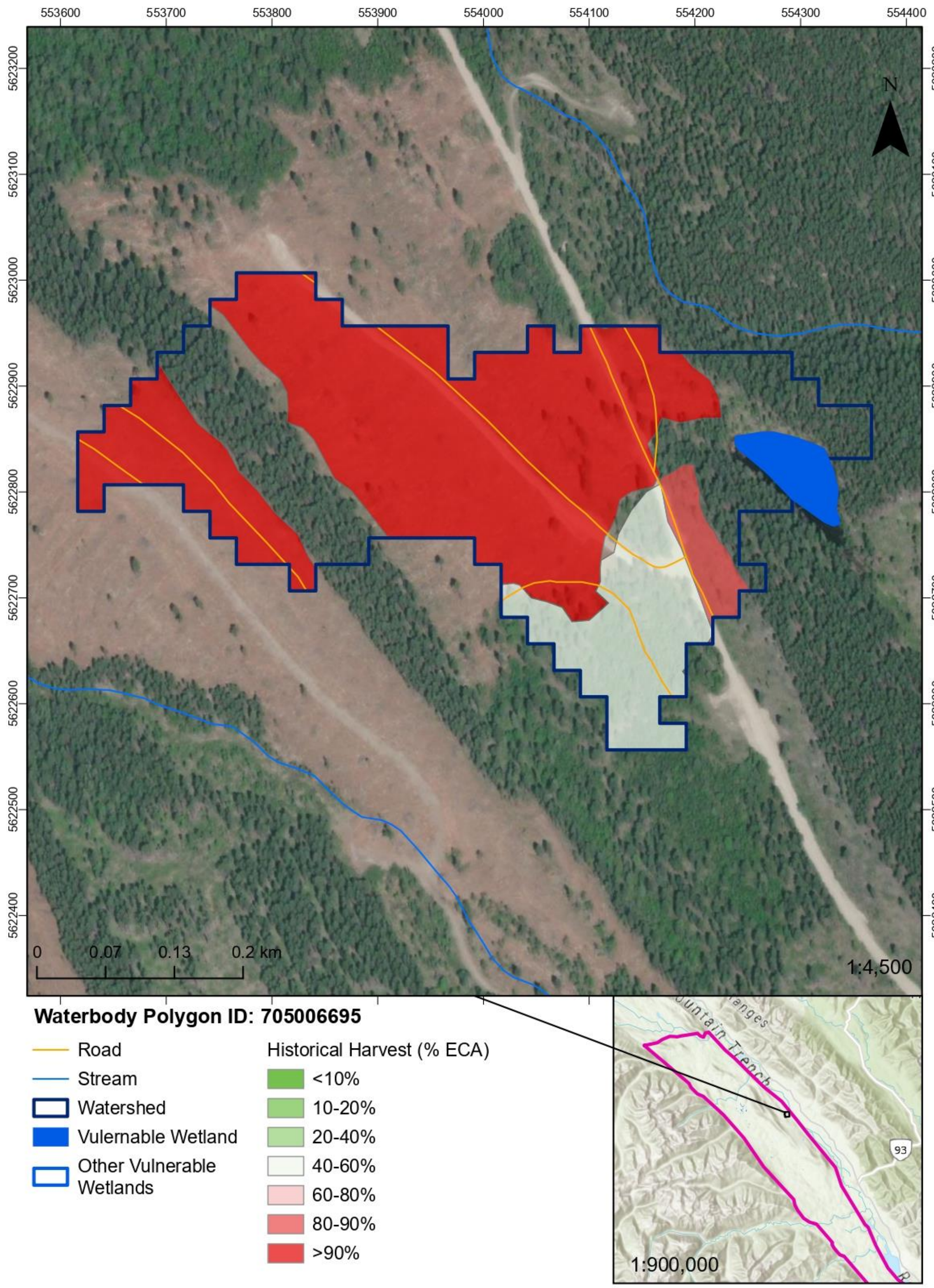
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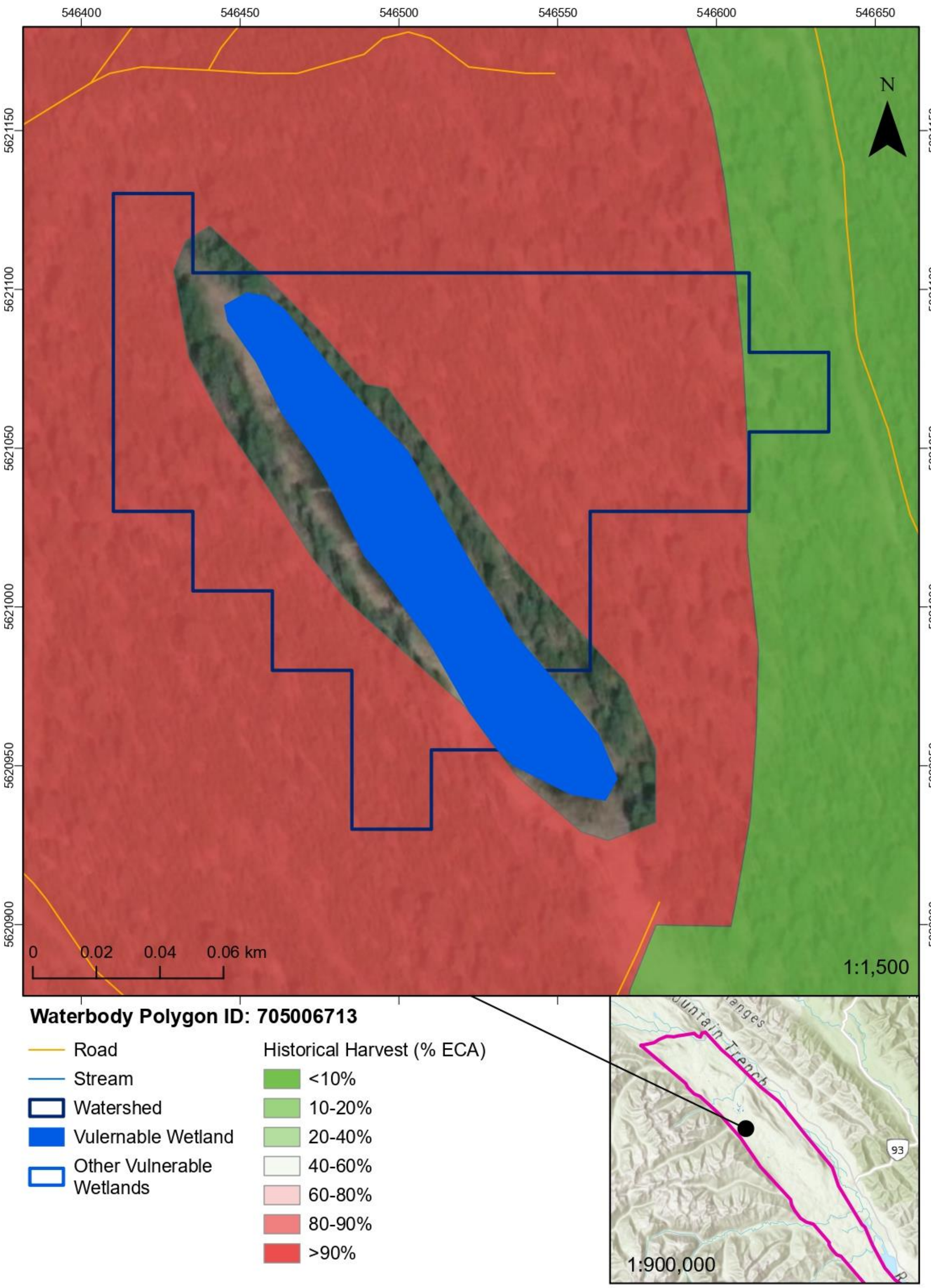
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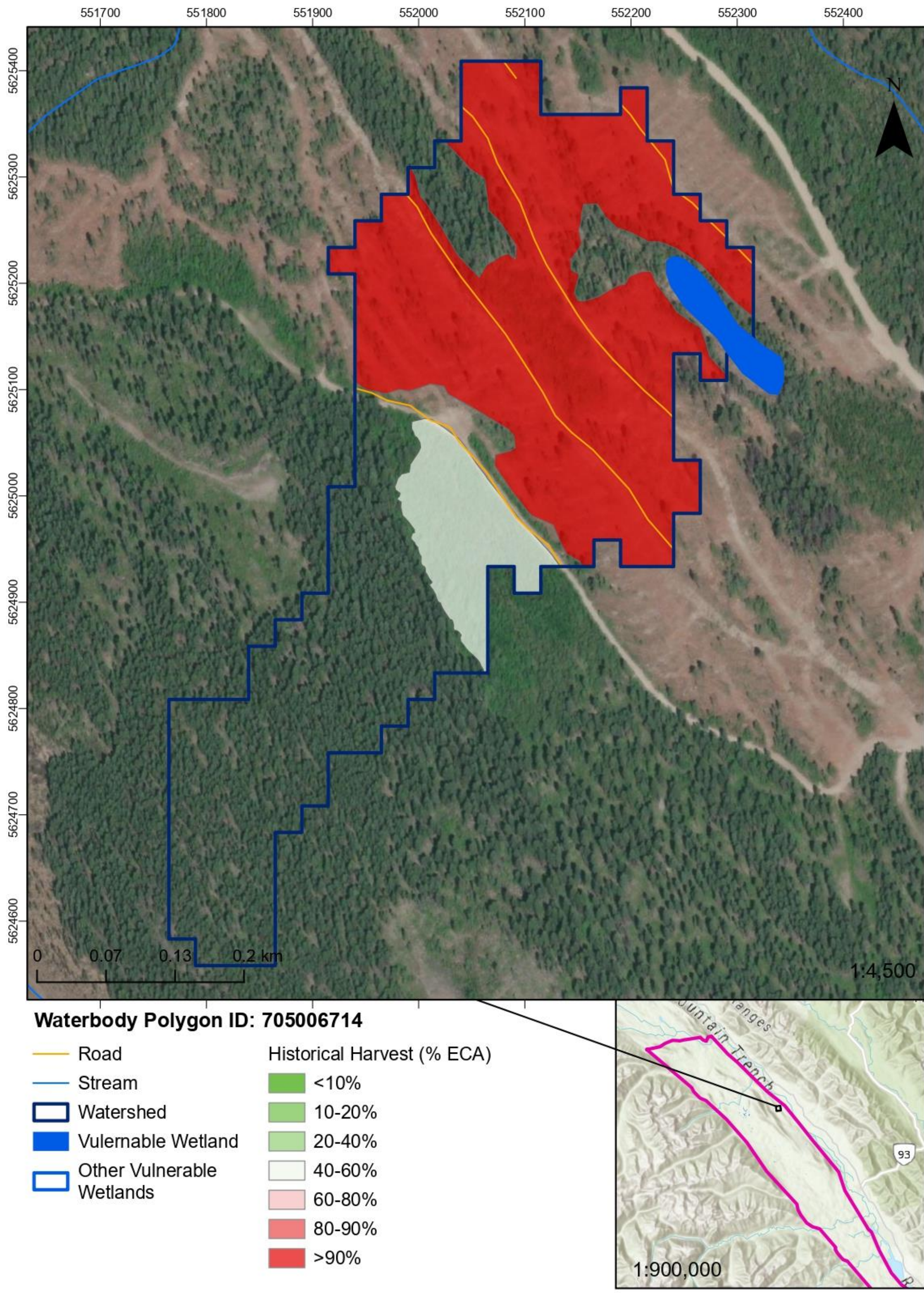
546600
546650
5621150
5621100
5621050
5621000
5620950
5620900
N
0
0.02
0.04
0.06 km
1:1,500
Waterbody Polygon ID: 705006713
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
<10%
10-20%
20-40%
40-60%
60-80%
80-90%
>90%
1:900,000
93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5624900
5624800
5624700
5624600
N
0 0.07 0.13 0.2 km
1:4,500
Waterbody Polygon ID: 705006714
Road
Stream
Watershed
Vulnerable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
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>90%
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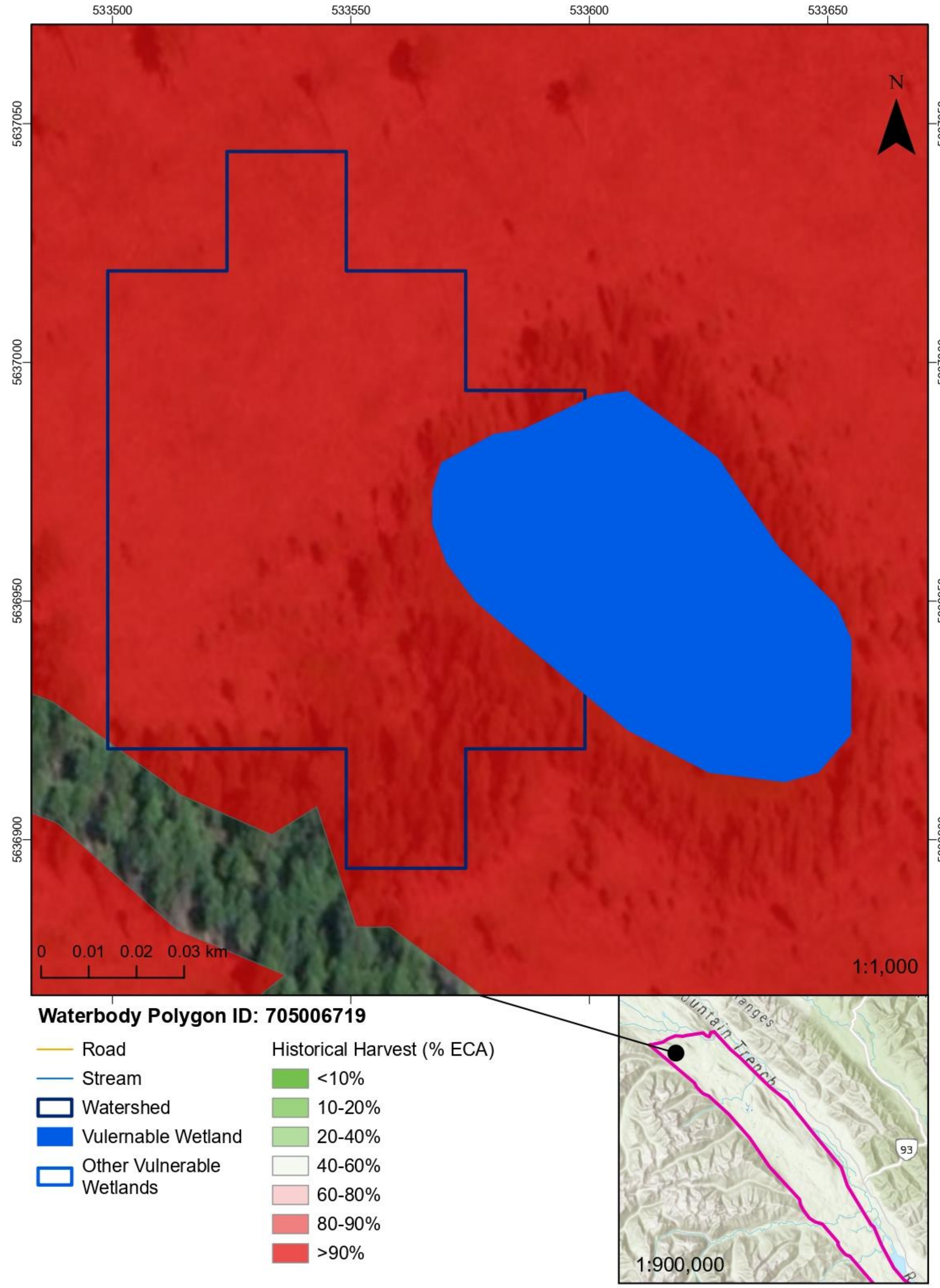
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5636950
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1:1,000
Waterbody Polygon ID: 705006719
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
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10-20%
20-40%
40-60%
60-80%
80-90%
>90%
93
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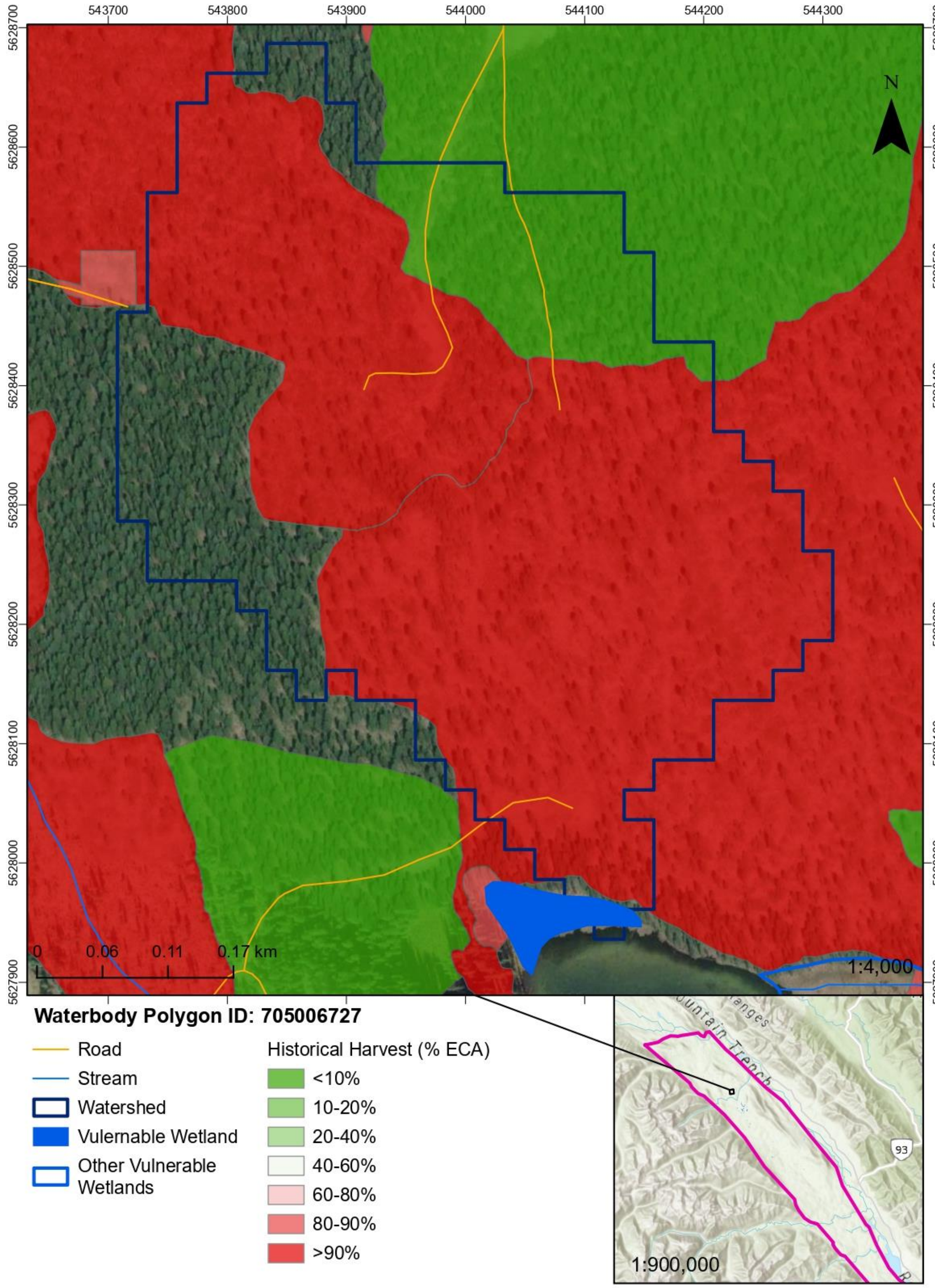

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544200
544300
5628700
5628600
5628500
5628400
5628300
5628200
5628100
5628000
5627900
N
0
0.06
0.11
0.17 km
1:4,000
Waterbody Polygon ID: 705006727
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
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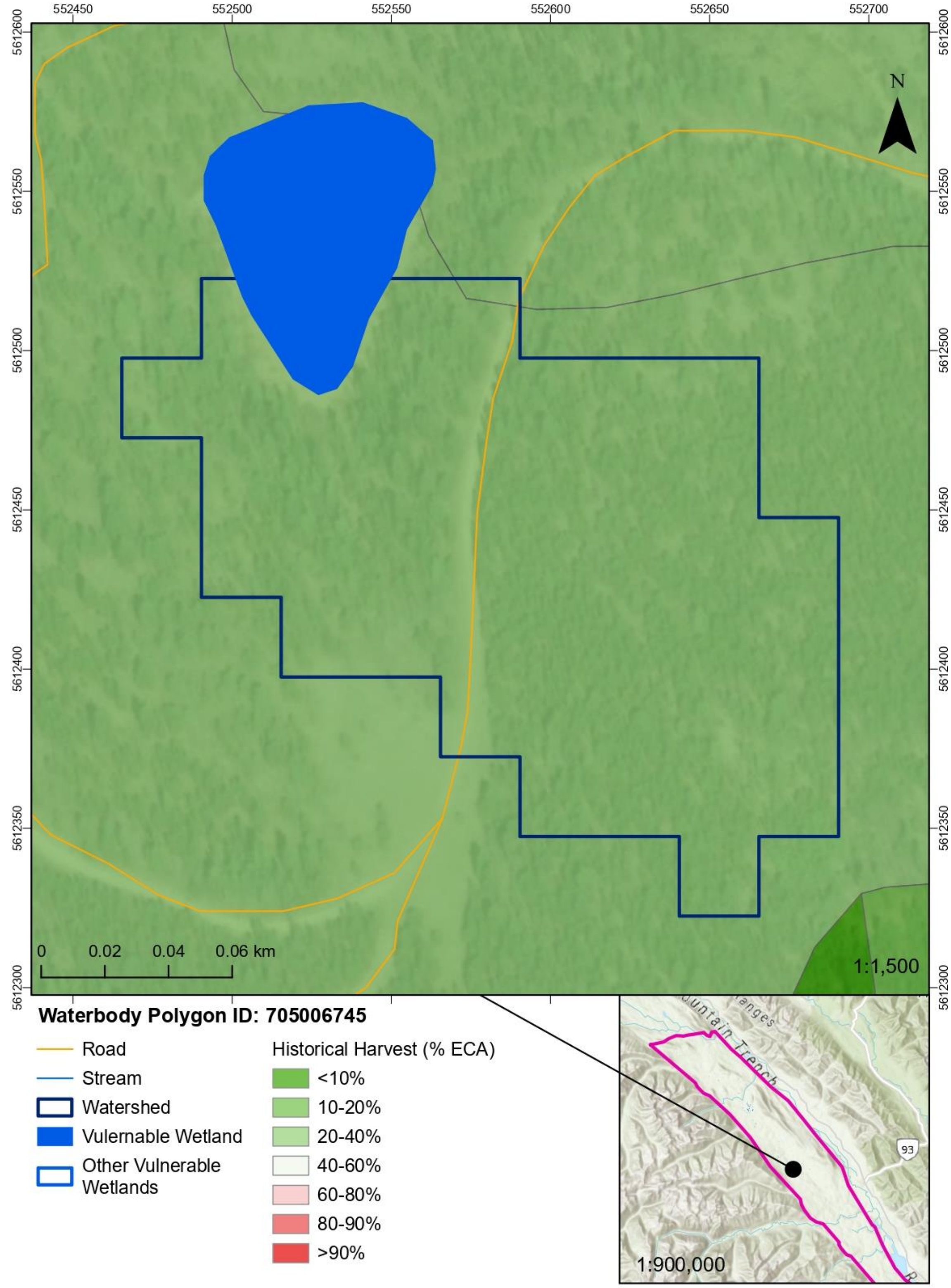
10-20%
20-40%
40-60%
60-80%
80-90%
>90%
1:900,000
93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552500
552550
552600
552650
552700
5612600
5612550
5612500
5612450
5612400
5612350
5612300
N
0
0.02
0.04
0.06 km
1:1,500
Waterbody Polygon ID: 705006745
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
<10%
10-20%
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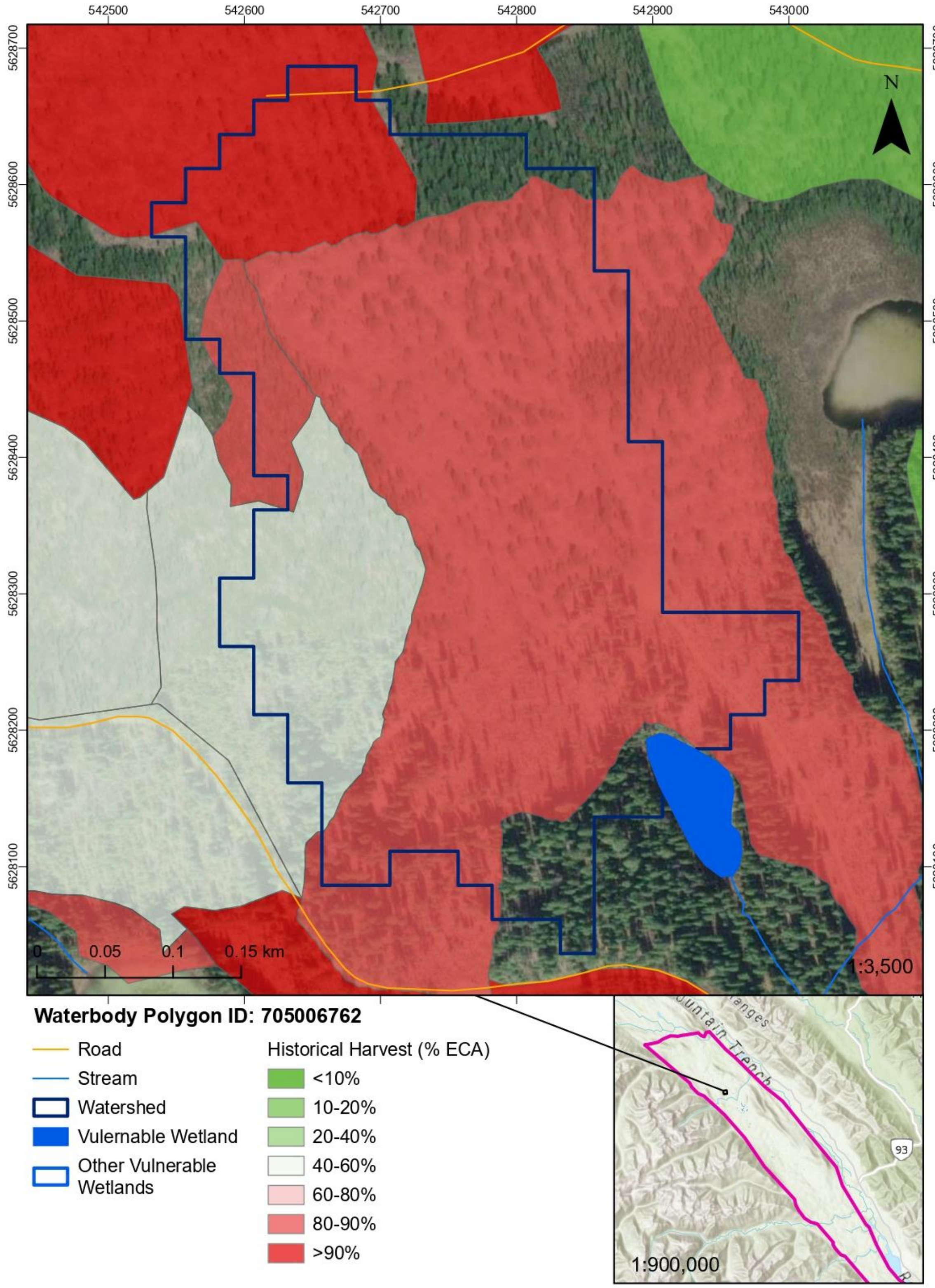
>90%
1:900,000
93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542600
542700
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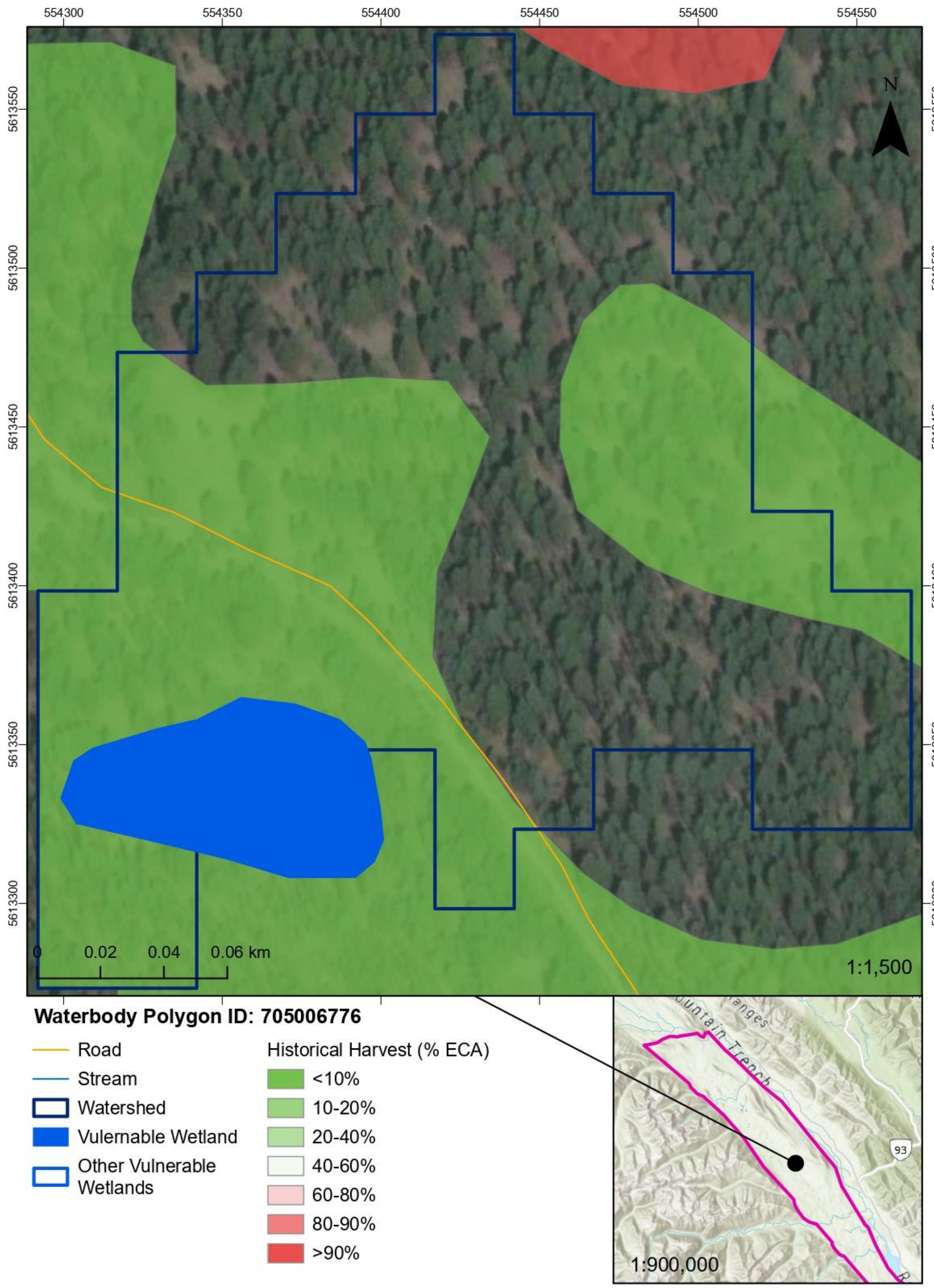
542900
543000
5628700
5628600
5628500
5628400
5628300
5628200
5628100
N
0
0.05
0.1
0.15 km
1:3,500
Waterbody Polygon ID: 705006762
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
<10%
10-20%
20-40%
40-60%
60-80%
80-90%
>90%
93
1:900,000



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554350
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554450
554500
554550
5613550
5613500
5613450
5613400
5613350
5613300
N
0
0.02
0.04
0.06 km
1:1,500
Waterbody Polygon ID: 705006776
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
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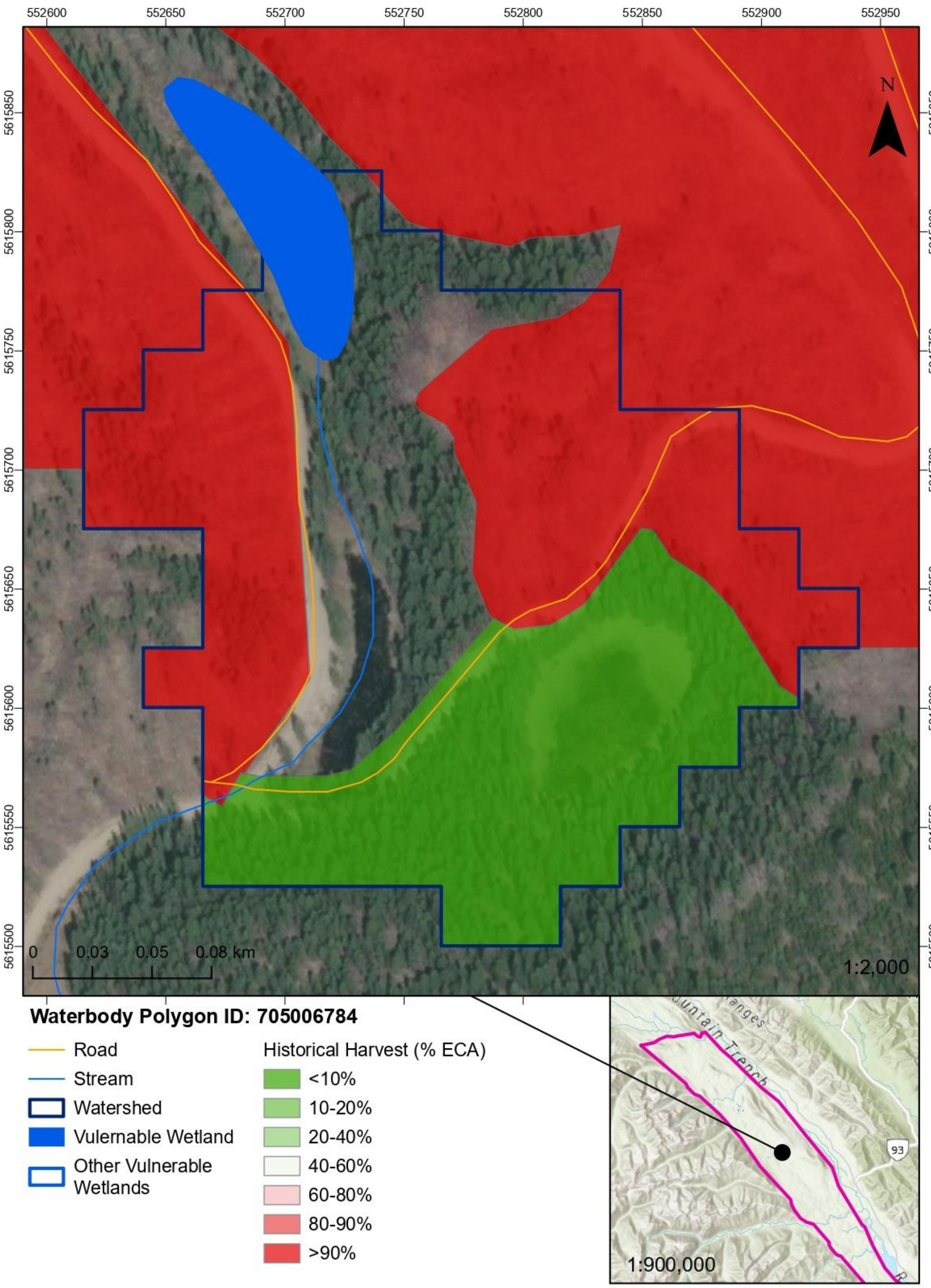
>90%
93
1:900,000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552650
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552850
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552950
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5615800
5615750
5615700
5615650
5615600
5615550
5615500
N
0 0.03 0.05 0.08 km
1:2,000
Waterbody Polygon ID: 705006784
Road
Stream
Watershed
Vulnerable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
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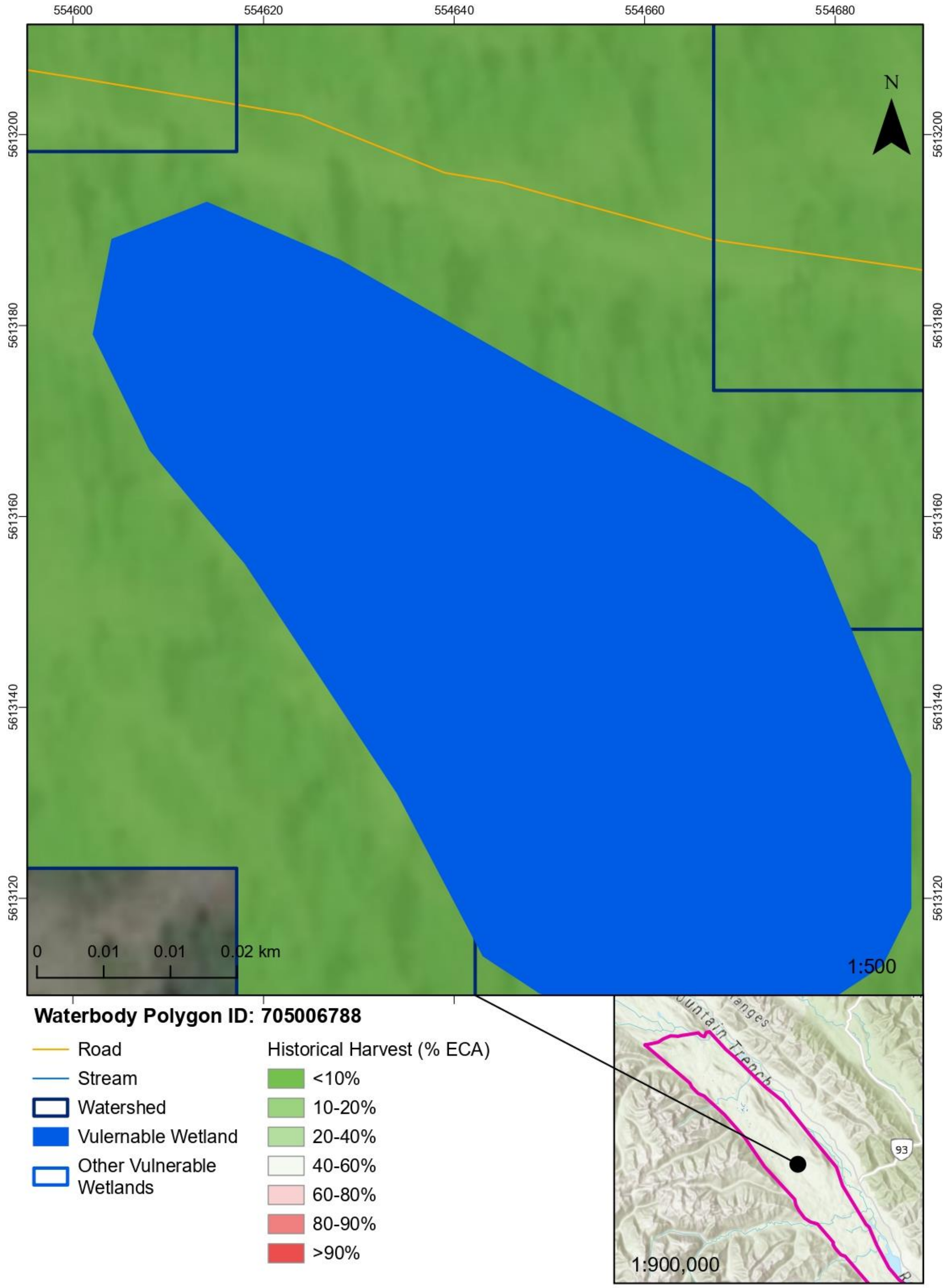
80-90%
>90%
93
1:900,000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554620
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554680
5613200
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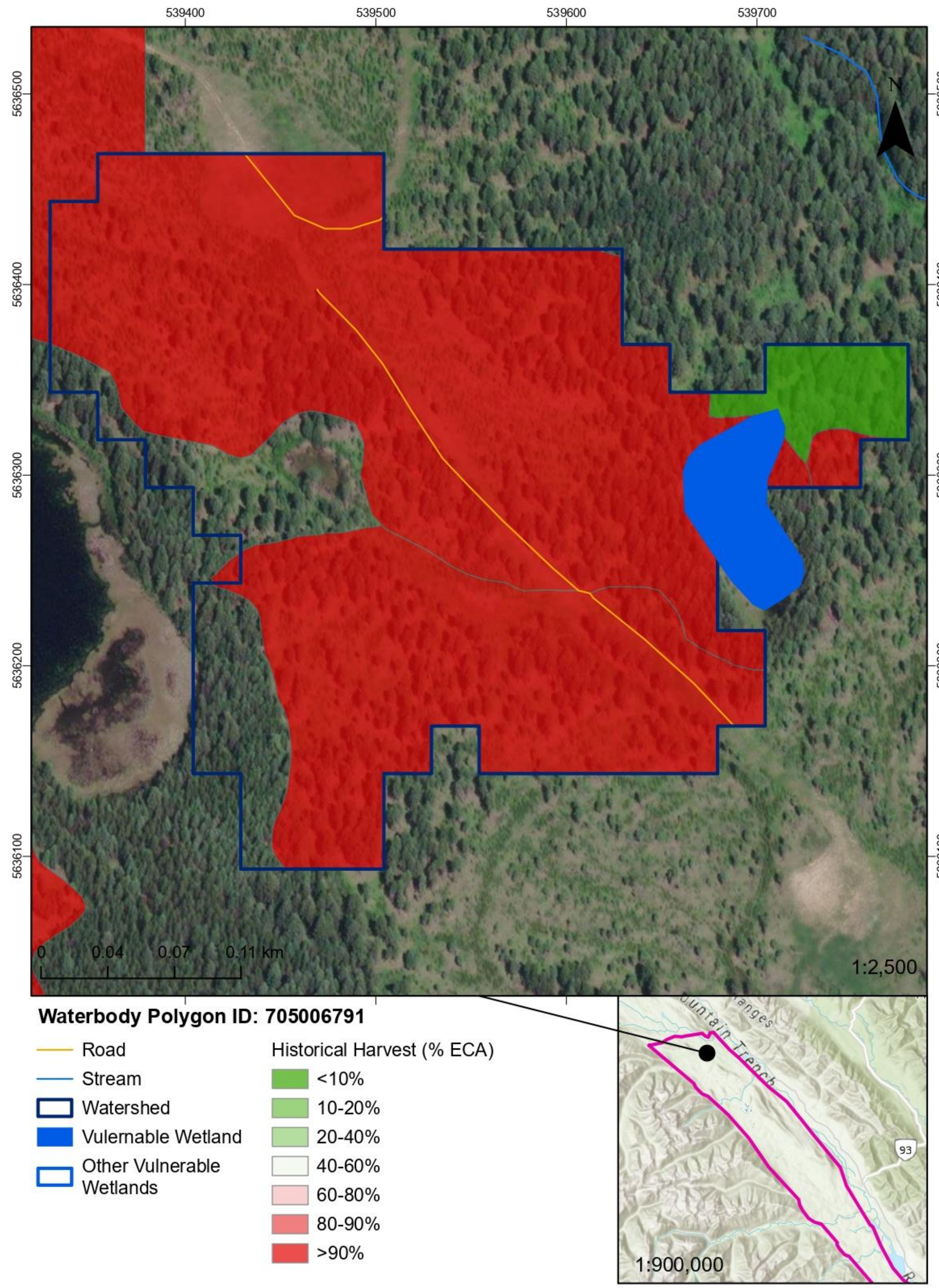
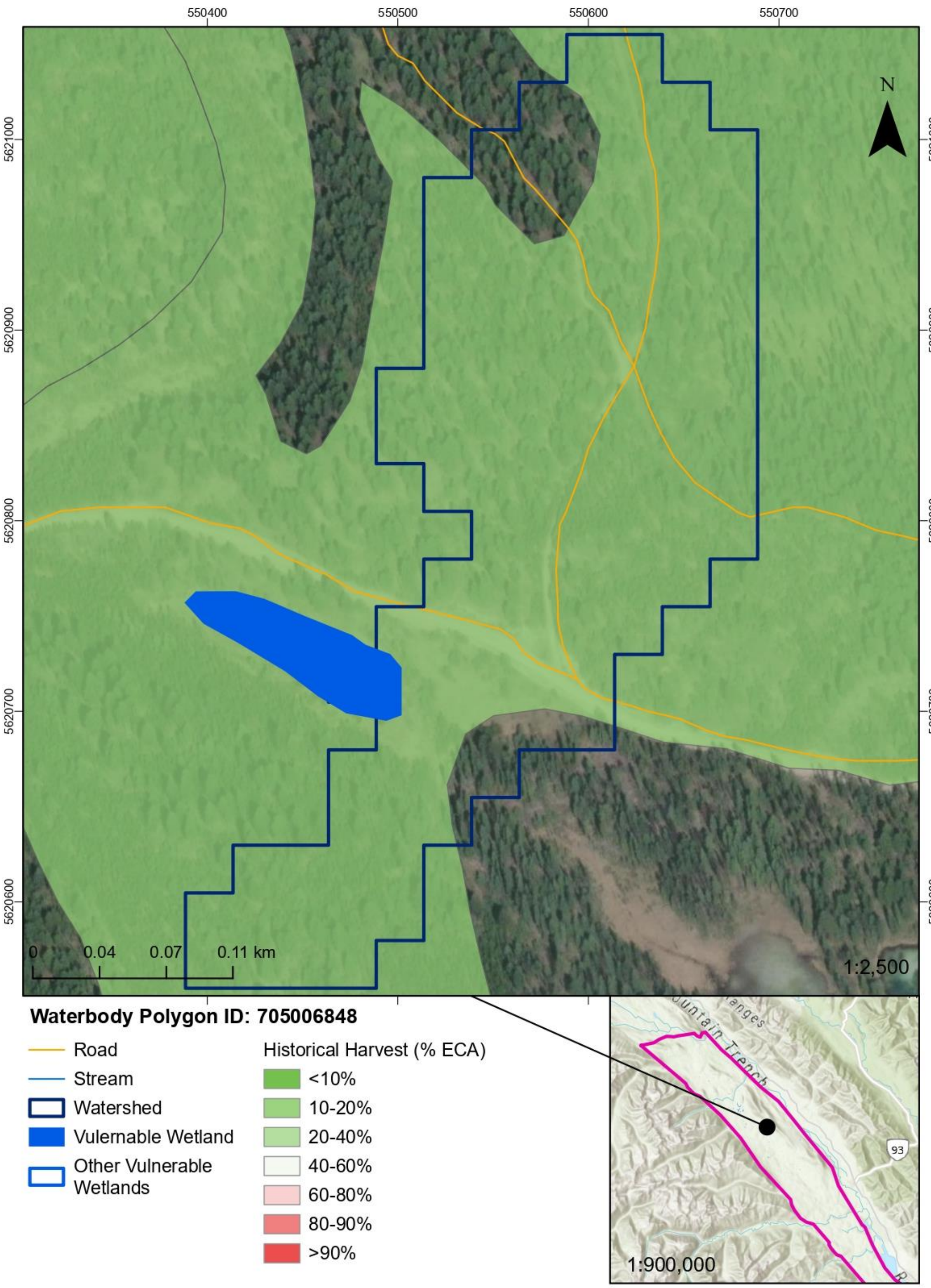
5613160
5613140
5613120
N
0 0.01 0.01 0.02 km
1:500
1:900,000
93
Waterbody Polygon ID: 705006788
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
<10%
10-20%
20-40%
40-60%
60-80%
80-90%
>90%



539400
539500
539600
539700
5636500
5636400
5636300
5636200
5636100
N
0 0.04 0.07 0.11 km
1:2,500
Waterbody Polygon ID: 705006791
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
<10%
10-20%
20-40%
40-60%
60-80%
80-90%
>90%
1:900,000
93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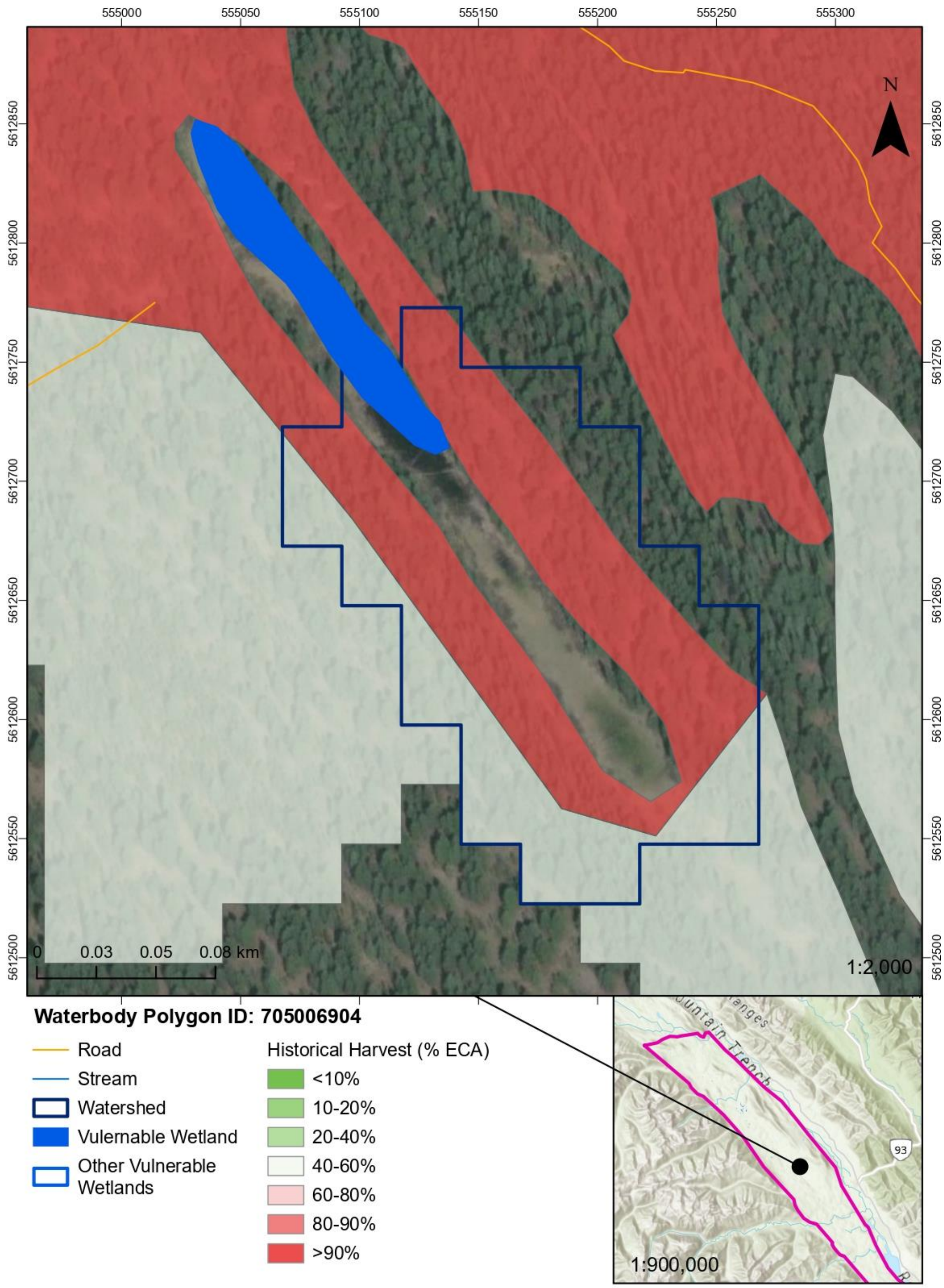
550500
550600
550700
5621000
5620900
5620800
5620700
5620600
N
0
0.04
0.07
0.11 km
1:2,500
Waterbody Polygon ID: 705006848
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
<10%
10-20%
20-40%
40-60%
60-80%
80-90%
>90%
93
1:900,000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555150
555200
555250
555300
5612850
5612800
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5612700
5612650
5612600
5612550
5612500
N
0 0.03 0.05 0.08 km
1:2,000
Waterbody Polygon ID: 705006904
Road
Stream
Watershed
Vulnerable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
<10%
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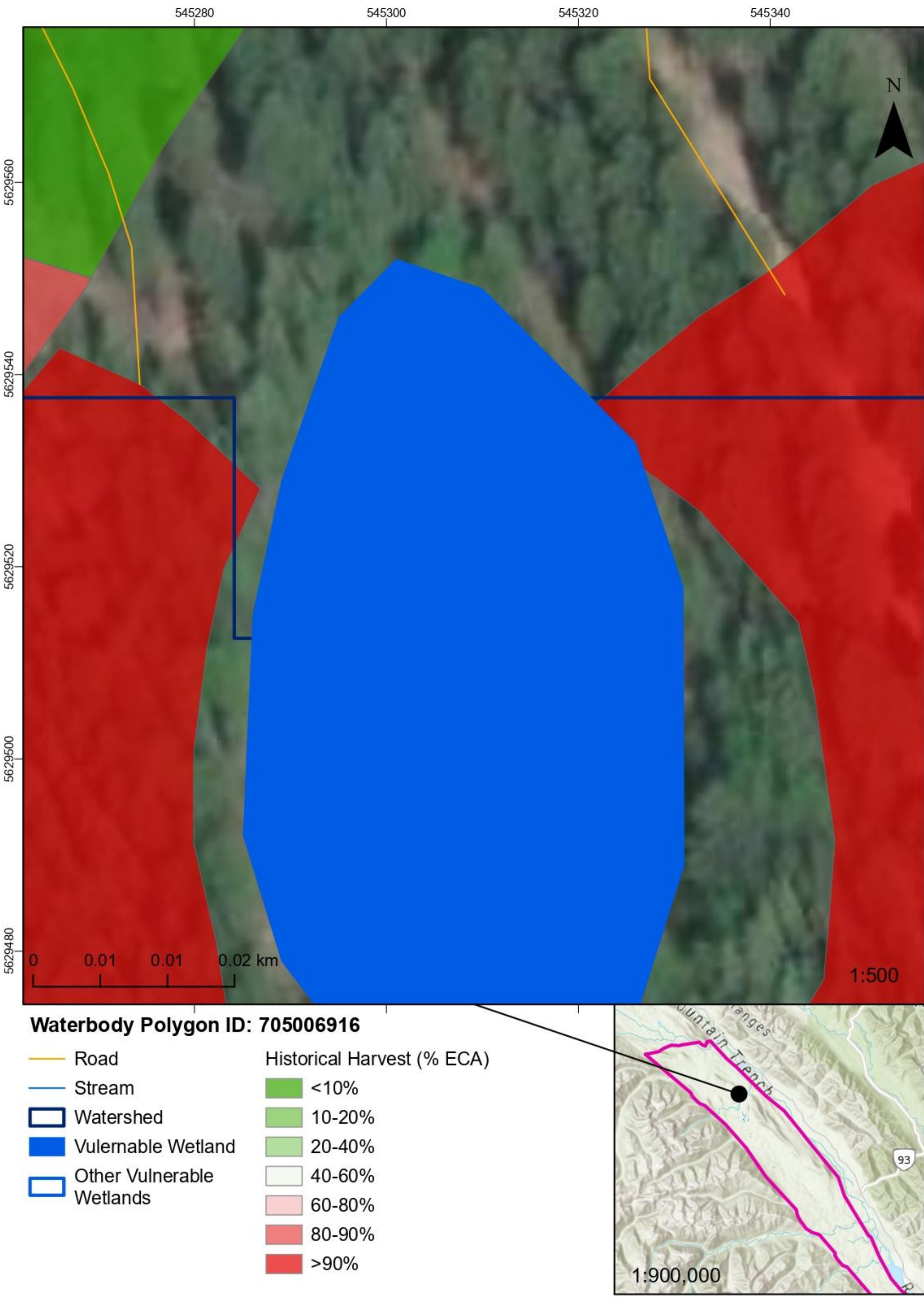
>90%
93
1:900,000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545300
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545340
5629560
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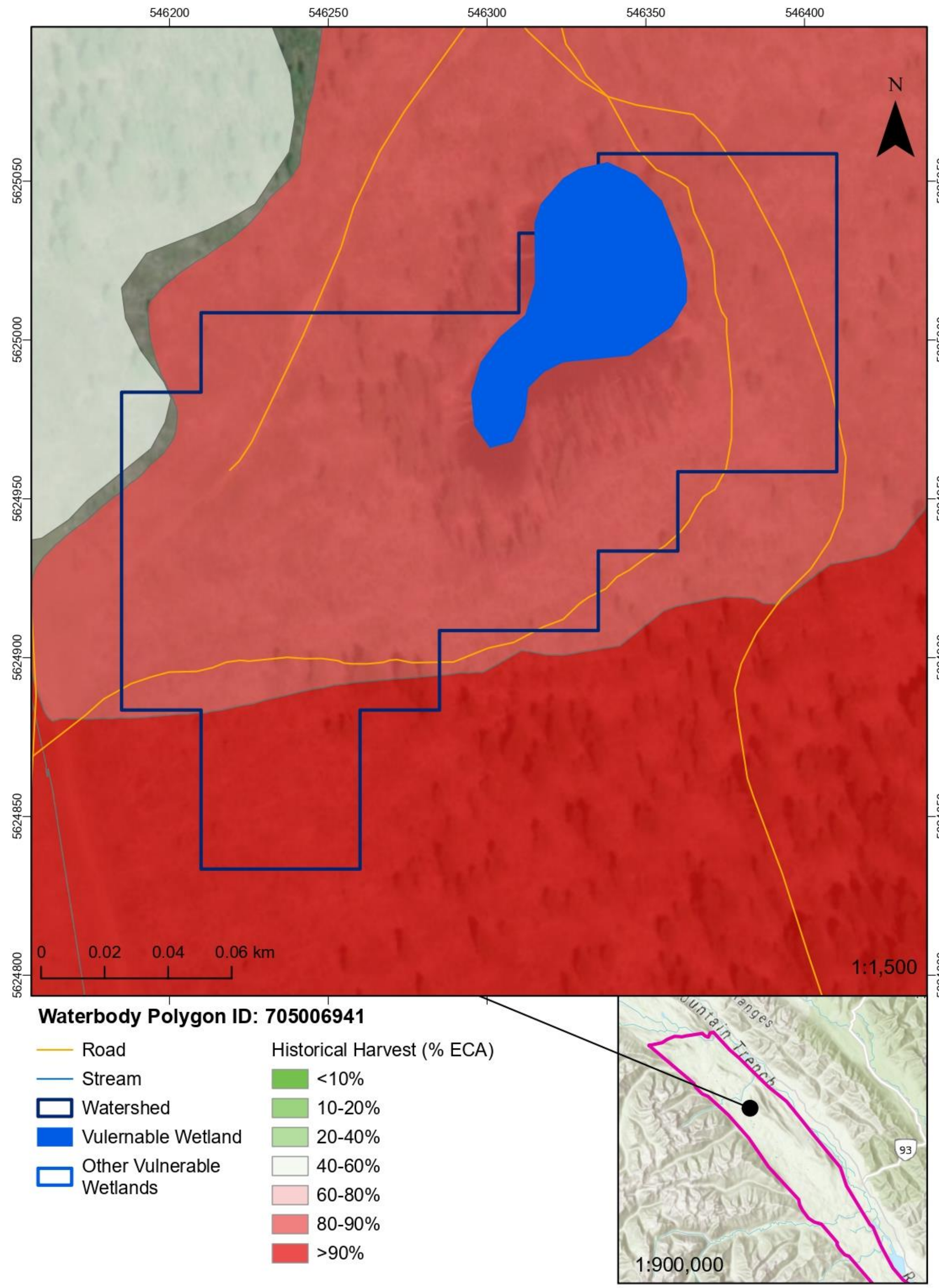
5629500
5629480
N
0 0.01 0.01 0.02 km
1:500
Waterbody Polygon ID: 705006916
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
<10%
10-20%
20-40%
40-60%
60-80%
80-90%
>90%
93
1:900,000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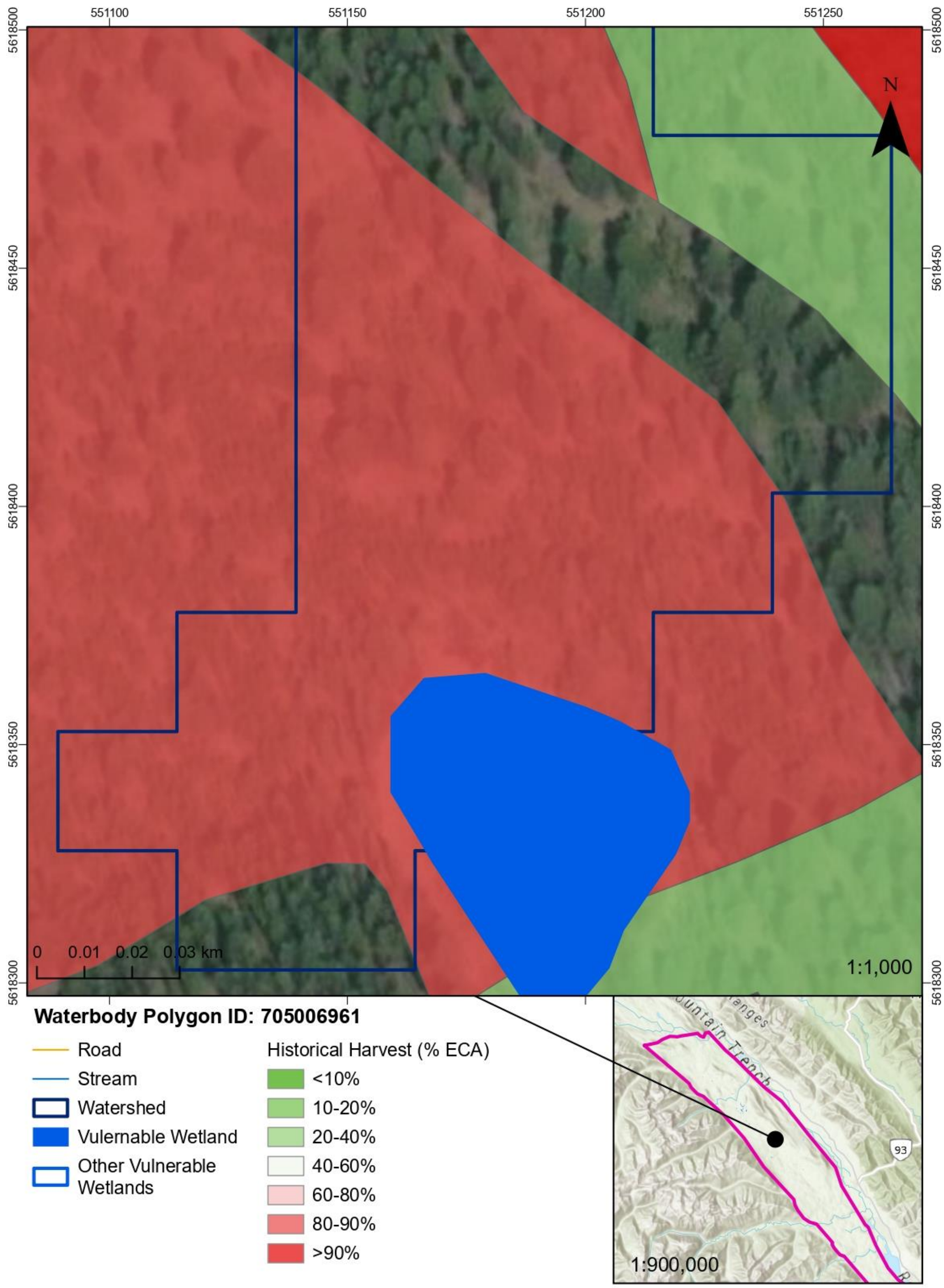
546250
546300
546350
546400
5625050
5625000
5624950
5624900
5624850
5624800
N
0 0.02 0.04 0.06 km
1:1,500
Waterbody Polygon ID: 705006941
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
<10%
10-20%
20-40%
40-60%
60-80%
80-90%
>90%
Mountain Trench
93
1:900,000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551200
551250
5618500
5618450
5618400
5618350
5618300
N
0 0.01 0.02 0.03 km
1:1,000
Waterbody Polygon ID: 705006961
Road
Stream
Watershed
Vulnerable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
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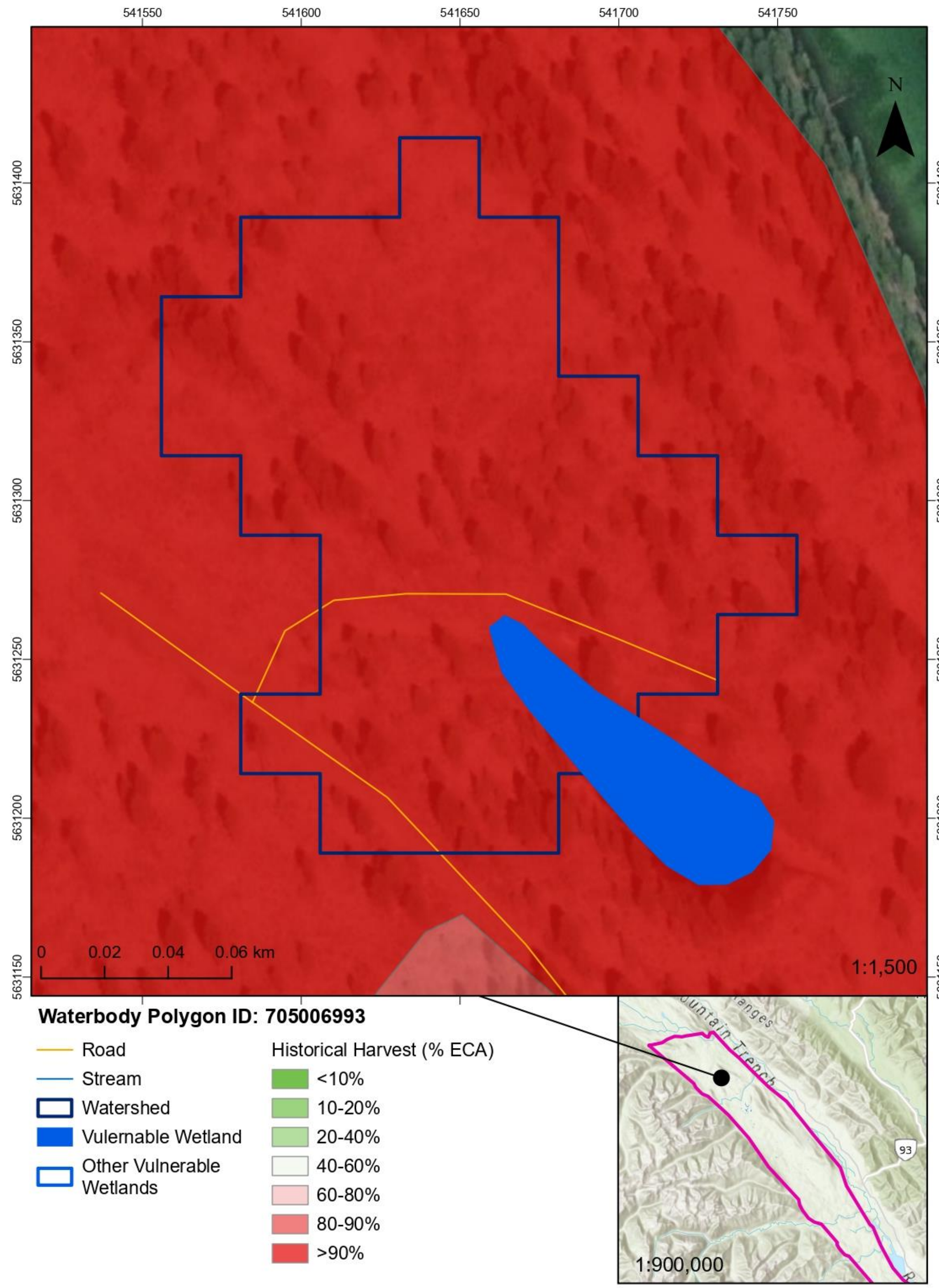
>90%
93
1:900,000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541750
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5631350
5631300
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5631200
5631150
N
0
0.02
0.04
0.06 km
1:1,500
Waterbody Polygon ID: 705006993
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
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10-20%
20-40%
40-60%
60-80%
80-90%
>90%
1:900,000
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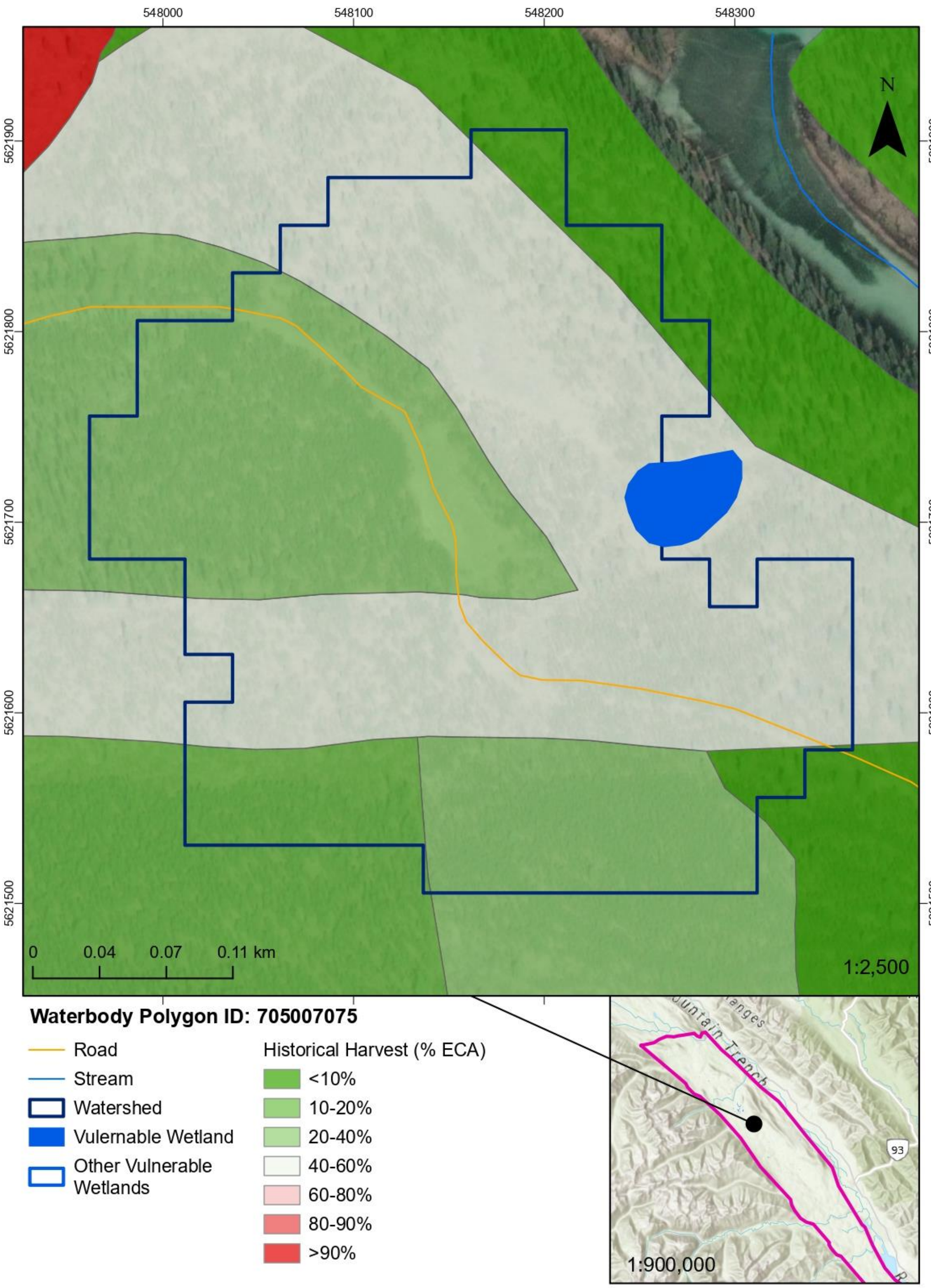

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548100
548200
548300
5621900
5621800
5621700
5621600
5621500
N
0 0.04 0.07 0.11 km
1:2,500
Waterbody Polygon ID: 705007075
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
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10-20%
20-40%
40-60%
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80-90%
>90%
93
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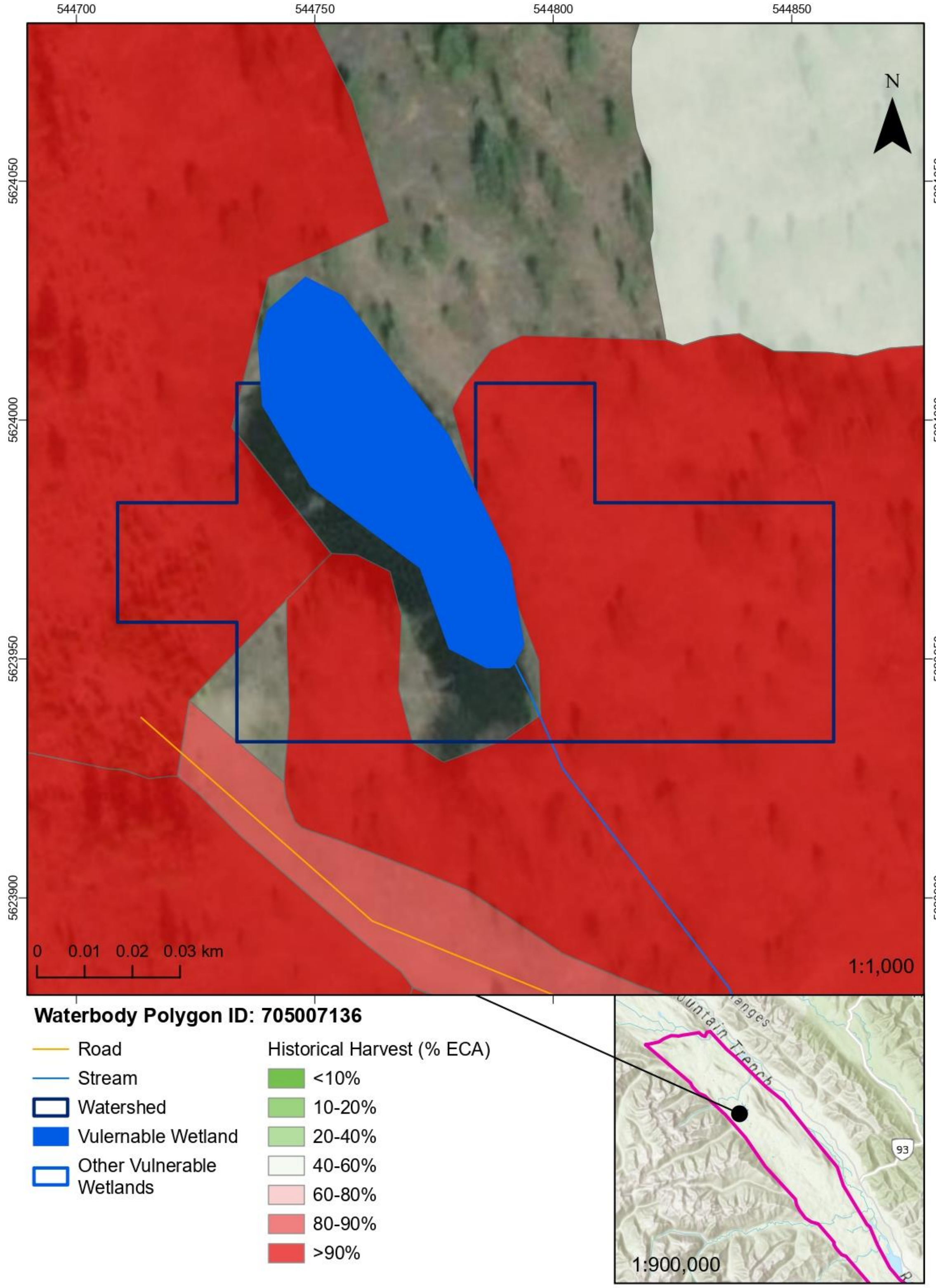
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544750
544800
544850
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5623950
5623900
N
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1:1,000
Waterbody Polygon ID: 705007136
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
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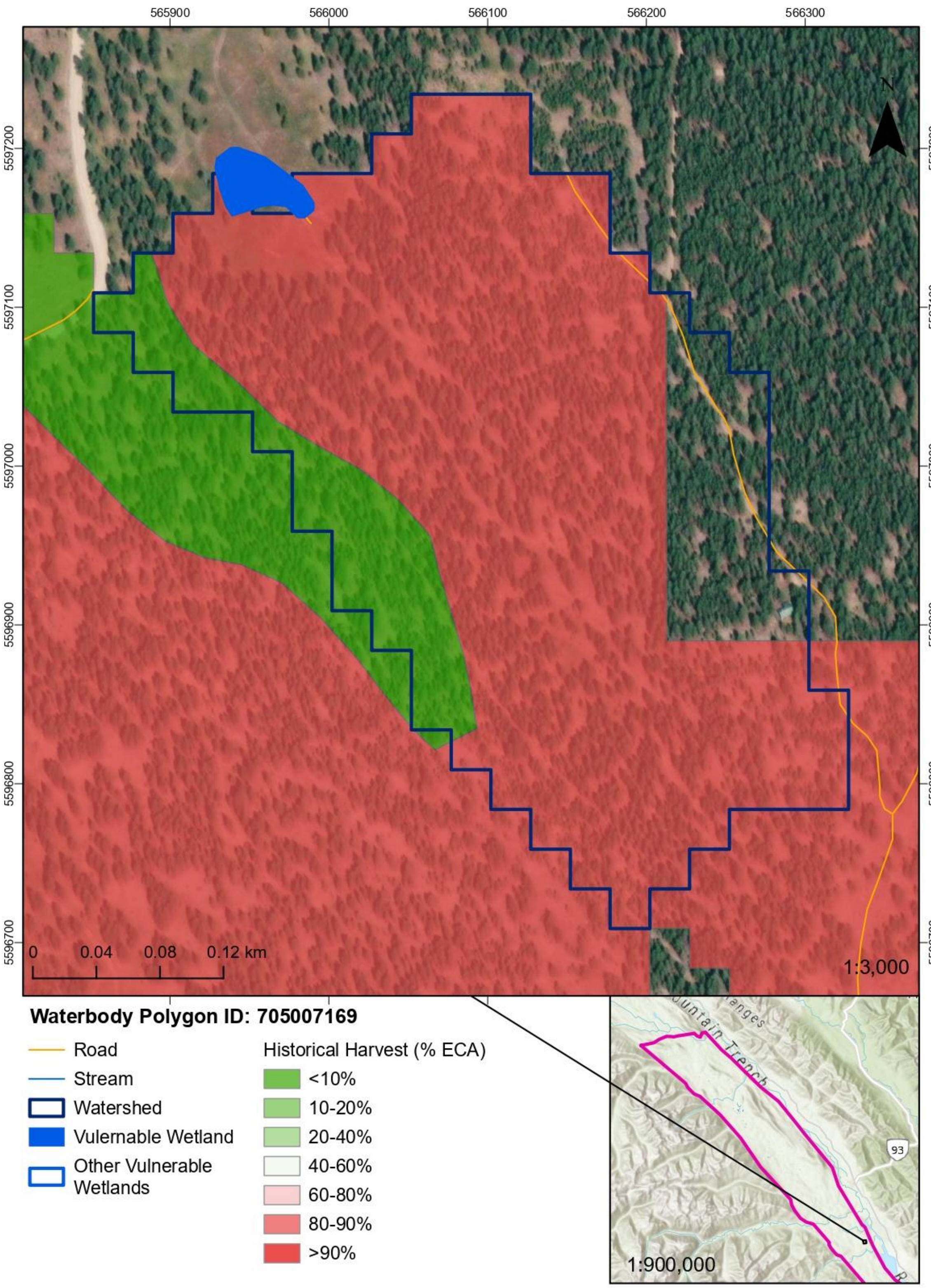
10-20%
20-40%
40-60%
60-80%
80-90%
>90%
1:900,000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5597000
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5596700
0 0.04 0.08 0.12 km
1:3,000
Waterbody Polygon ID: 705007169
Road
Stream
Watershed
Vulnerable Wetland
Other Vulnerable Wetlands
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>90%
1:900,000
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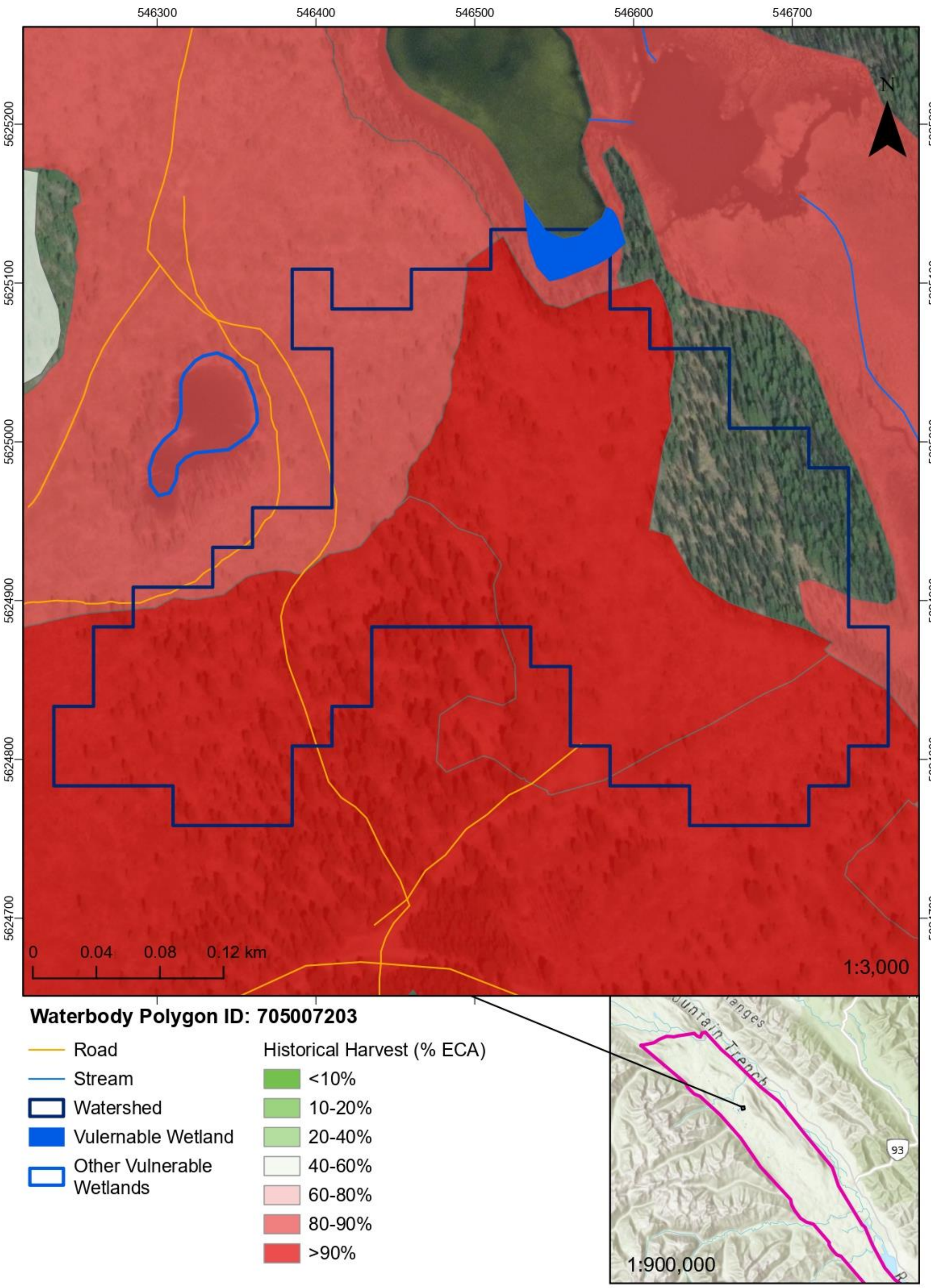
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N
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1:3,000
Waterbody Polygon ID: 705007203
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
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93
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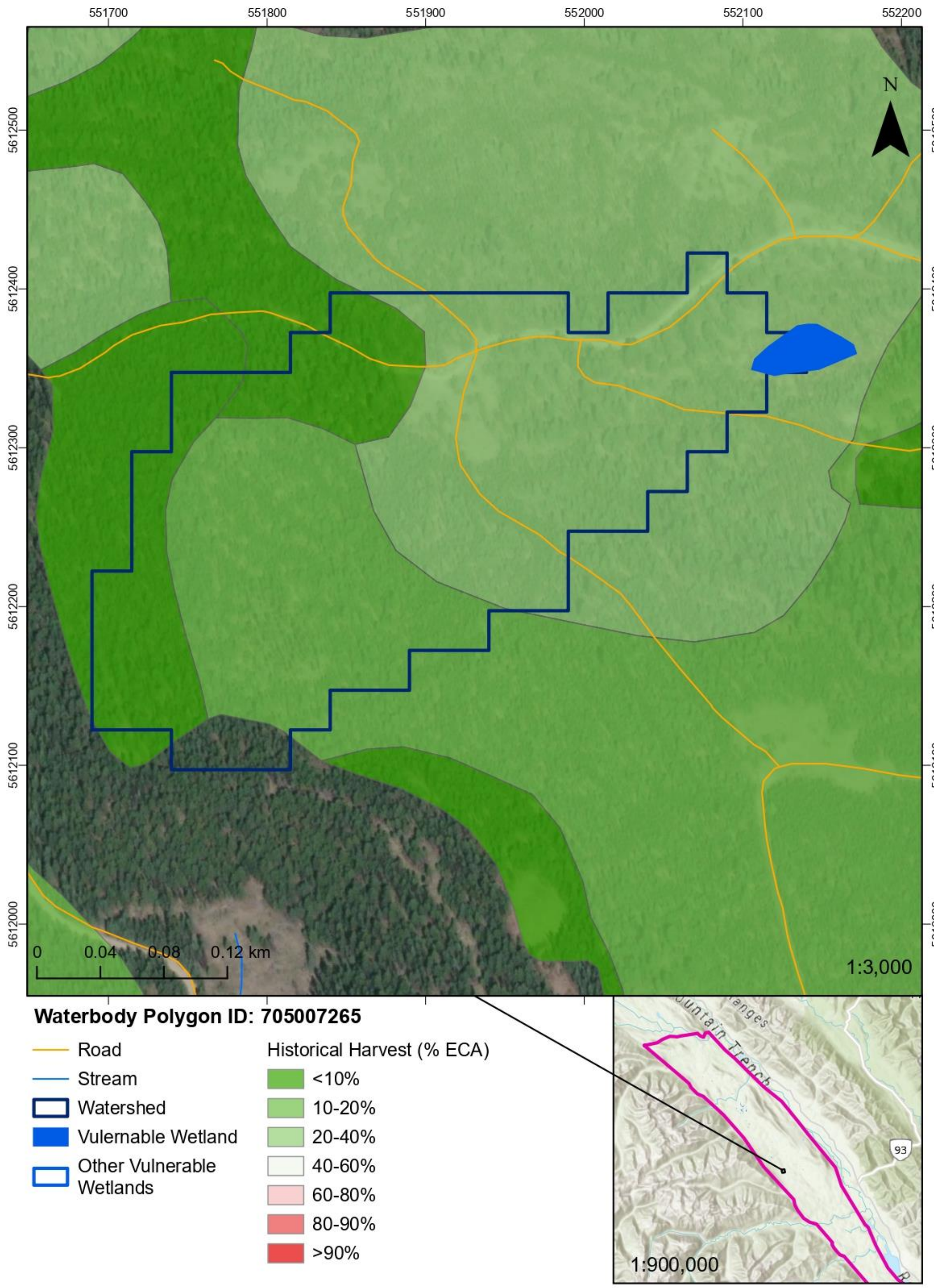
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1:3,000
Waterbody Polygon ID: 705007265
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
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>90%
93
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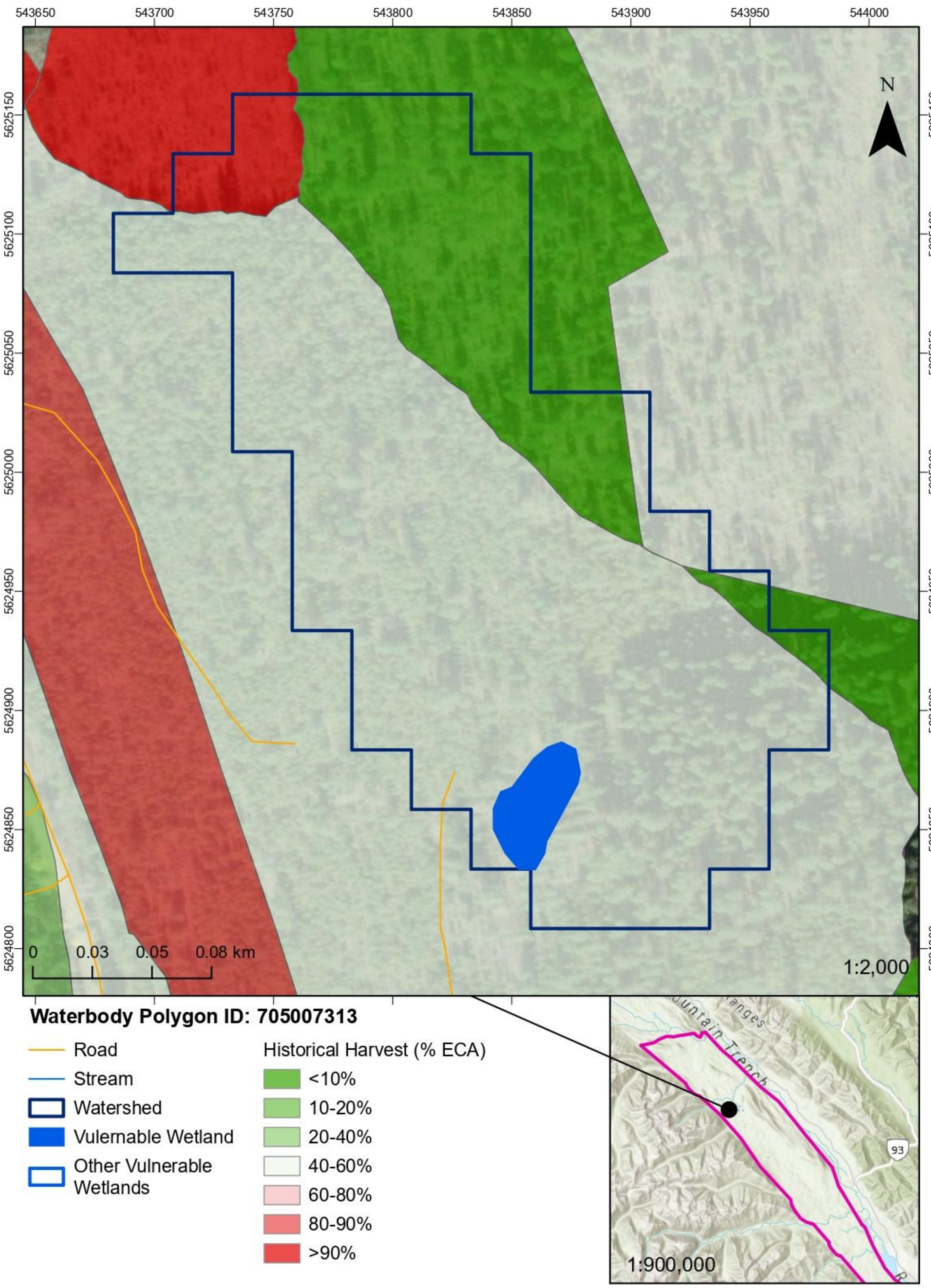
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543950
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5624900
5624850
5624800
N
0 0.03 0.05 0.08 km
1:2,000
1:900,000
93
Waterbody Polygon ID: 705007313
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
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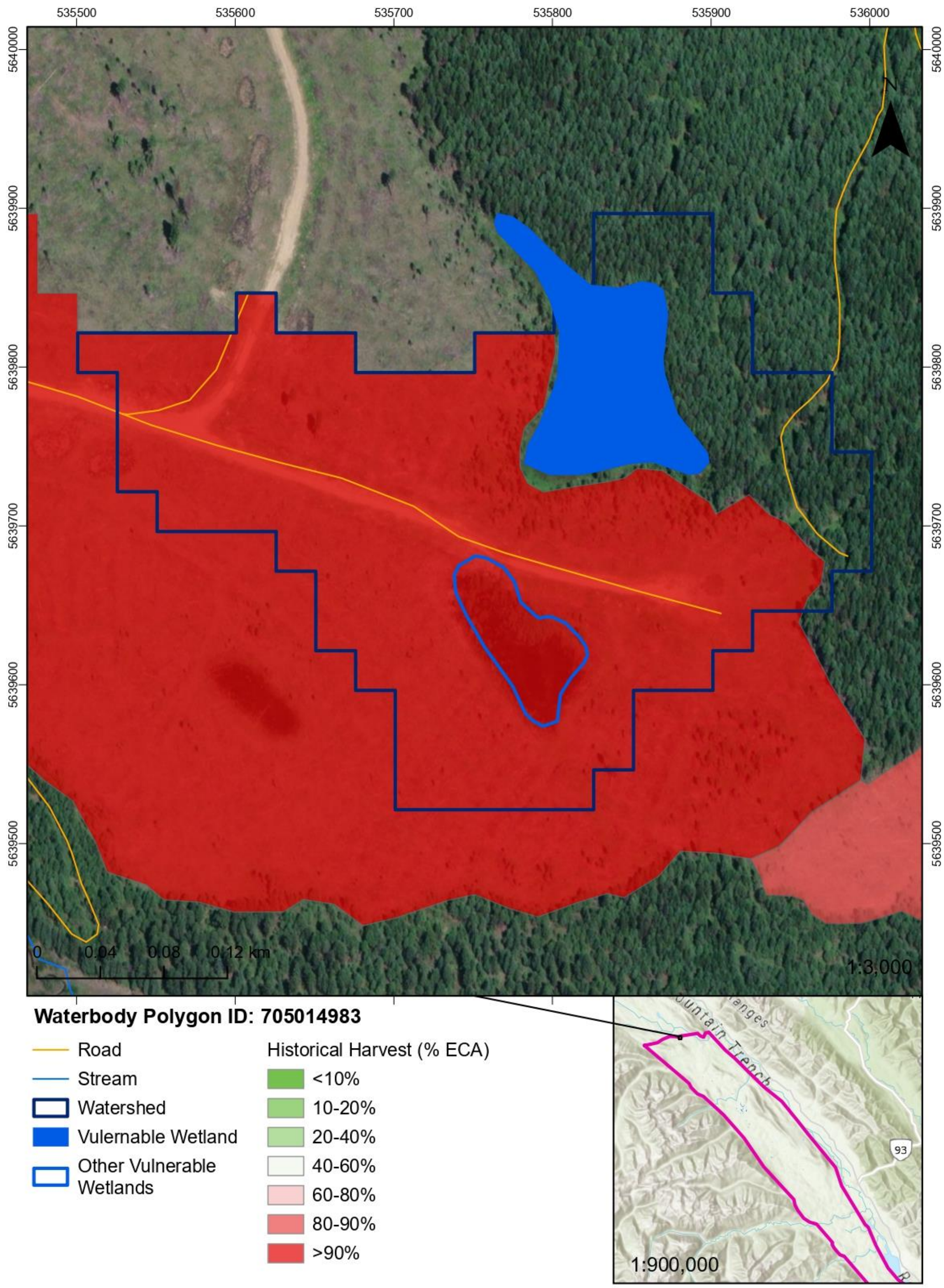
60-80%
80-90%
>90%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535600
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535800
535900
536000
5640000
5639900
5639800
5639700
5639600
5639500
0 0.04 0.08 0.12 km
1:3,000
Waterbody Polygon ID: 705014983
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
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>90%
93
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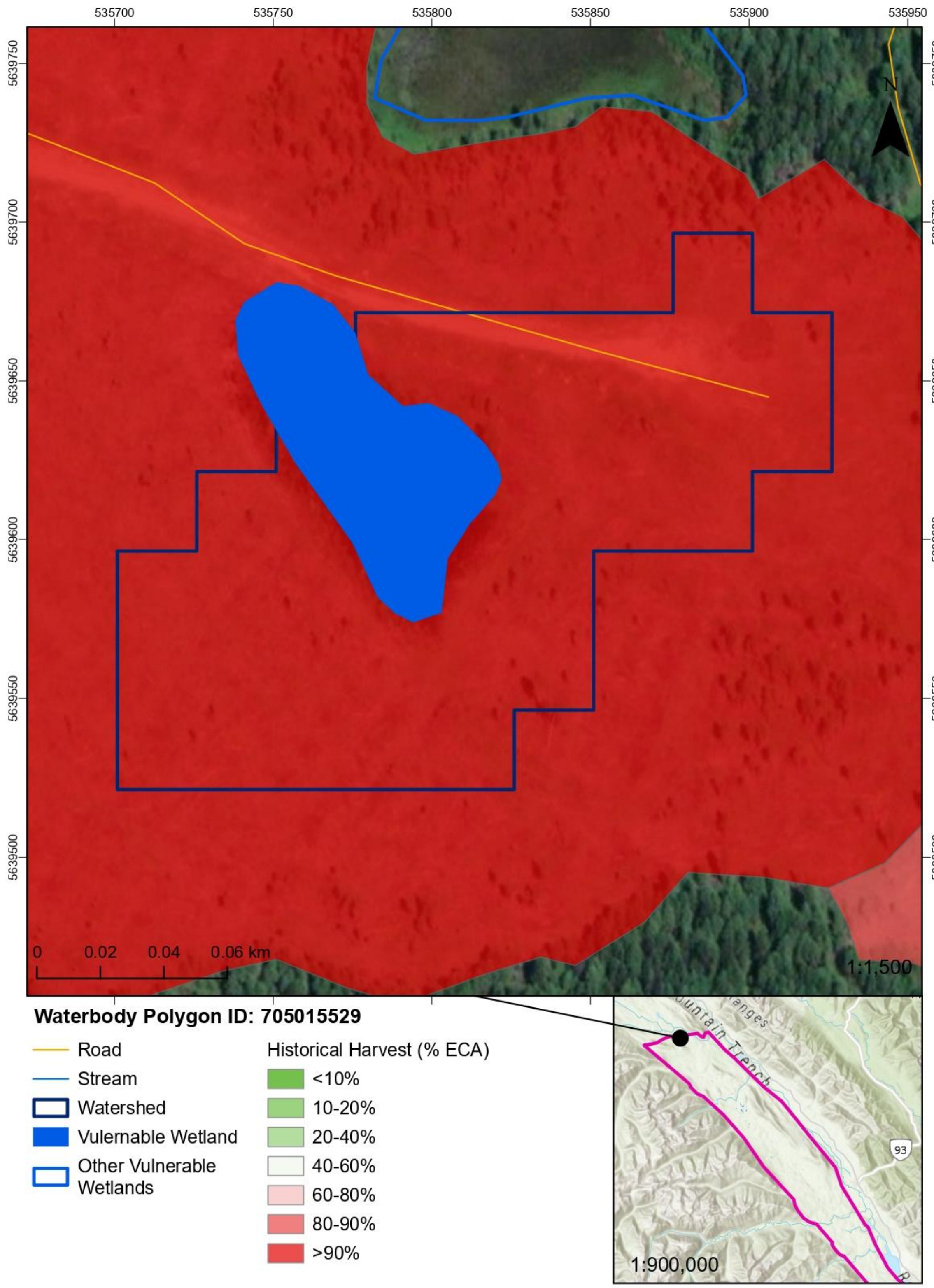
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5639700
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5639550
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0 0.02 0.04 0.06 km
1:1,500
N
1:900,000
93
Waterbody Polygon ID: 705015529
Road
Stream
Watershed
Vulernable Wetland
Other Vulnerable Wetlands
Historical Harvest (% ECA)
<10%
10-20%
20-40%
40-60%
60-80%
80-90%
>90%