

Impacts of the Bush Creek East Fire on Adams River Sockeye Salmon and their Spawning Habitat

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NRSC 4130

The increasing frequency and severity of wildfires in British Columbia is no new topic, and the impact from heightened activity is evident throughout the province. The diversity of post-fire effects varies across spatial scales (Bixby, et al. 2015) and poses catastrophic impacts for social, economic and environmental systems (Cooke, et al. 2023). Since the perception of fire consequences often aligns with human values (Bixby, et al. 2015), it is easier to grasp the extent of damage when the effects are physically observed - such as smoke plumes hindering visibility and degrade air quality or the risk of property loss. In contrast, aquatic ecosystems - whose impacts that are less visually apparent - tend to receive less attention than terrestrial ecosystems (Gomez Isaza, Cramp and Franklin 2022; Ward, et al. 2022). Despite being some of the most threatened and biodiverse habitats (Johnson, et al. 2024), there is a lack of knowledge around how wildfires affect aquatic species, how different fire-related impacts interact, and how long these effects last (Gomez Isaza, Cramp and Franklin, 2022). The impacts to aquatic environments are complex, and vary based on fire characteristics (extent, severity, and duration) and local watershed properties (physical, biochemical and chemical) (Cooke, et al. 2023). However, the effects on riparian vegetation, sediment controls, streambank stabilization, large woody debris (LWD), nutrient inputs and microclimates (Cederholm, et al. 2001) are linked to immediate declines of fish, amphibians, and invertebrate populations following a wildfire (Bixby, et al. 2015)

One such ecosystem of concern is the Adams River within Tsútswecw Provincial Park. This critical spawning habitat hosts one of the largest sockeye salmon runs in North America (BC Parks, 2024). These salmon rely on cool, well-oxygenated water and particular gravel substrates in their natal watersheds, all of which are sensitive to post-fire changes, such as increased sedimentation, decreased water quality, and increased water temperatures. This is a key concern due to the 20-year trend of declining sockeye salmon abundance and productivity across the Pacific coast (Martins, et al. 2012). Given a century of land-use changes and intensifying effects of climate change on fire regimes (Bixby, et al. 2015; Siegel and Crozier, 2019), it is

critical to understand the impacts in order to preserve biodiversity and maintain ecosystem health in the Pyrocene (Erdozain, Cardil and de-Miguel, 2024). This paper will explore the impacts of the 2023 Bush Creek East Fire (K21633) on sockeye salmon and their spawning habitats in Tsútsweew Park, emphasizing the need for aquatic monitoring and habitat restoration to increase resiliency and adaptive capacity in a fire-prone future (Crozier and Siegel, 2023).

Sockeye Salmon Ecology

As one of the most iconic and valued species of Pacific salmon, sockeye (*Oncorhynchus nerka*) are integral to the culture and livelihoods of Pacific First Nations and play a critical role in food webs across marine and freshwater environments (Martins, et al. 2012). Their carcasses providing nutrients to countless species in estuaries, streams, and riparian forests, supporting broader ecosystem productivity (Massey, 2021). The lifespan of sockeye is four years, with anadromous individuals splitting their time between freshwater and marine environments, while freshwater residents (Kokanee) remain in freshwater - though they retain the ability to revert to anadromy under favourable conditions (Crozier and Siegel, 2023). There are five main stages in the anadromous sockeye salmon life history: 1) spawning and egg incubation over the winter; 2) freshwater rearing as fry, typically migrating to nearby nursery lakes to feed and grow; 3) seaward migration in the spring once they've transitioned to smolts; 4) ocean rearing, where they feed and mature for two or more years; 5) return migration to natal streams for spawning and deposit marine-derived nutrients into freshwater ecosystems (Cederholm, et al. 2001; Healey, 2011).

The timing and duration of life stages varies across populations, primarily due to differences in local habitat conditions (Crozier and Siegel, 2023). Behaviour, growth, and developmental rates exhibit significant plasticity in response to environmental variability (Crozier and Siegel, 2023). This variability in local conditions has driven the development of unique life-history strategies among populations, each adapted to maximize survival and reproductive success (Whitney, Hinch and Patterson, 2013). The thermal tolerance of sockeye is life stage-specific, highlighting the importance of habitat heterogeneity in order to meet the range of physiological needs throughout their life cycles (Whitney, Hinch and Patterson, 2013). Riparian areas play a vital role in maintaining suitable sockeye habitat quality. They regulate stream temperature through shading, stabilize banks with root systems, and filter sediments from upland runoff (Erdozain, Cardil and de-Miguel, 2024). These zones also contribute organic

matter, provide large woody debris for habitat structure, and mediate nutrient flow (Bixby, et al. 2015). Additionally riparian vegetations helps moderate microclimates, creating stable conditions and refugia zones for sockeye (Cederholm, et al. 2001).

Tsútswecw Provincial Park

Established in 1977, the Tsútswecw Provincial Park encompasses 1,059 hectares of river-eroded land in the North Shuswap (50°54'07.62"N 119°34'05.05"W) (BC Parks, 2024). The park is characterized by valley bottoms and delta riparian habitat – which is recognized as some of the most biologically diverse habitat, yet the most threatened in the Southern Interior (Ministry of Water, Land and Air Protection, 2002). Located in the Interior Douglas-fir (IDF) biogeoclimatic zone, 818 ha in the very hot, dry (IDF_{hx1}) subvariant, while the remaining 258 hectares are classified as moist, warm (IDF_{mw2}) (Ministry of Water, Land and Air Protection, 2002). The large, steadily flowing Adams River runs through the park before entering the Shuswap Lake. It is fed by several tributaries, including Hiuihill Creek and Nikwikaia (Ministry of Water, Land and Air Protection, 2002). The area supports a variety of birds and mammals, including black bears, beavers, bald eagles, river otters, whitetail and mule deer (BC Parks, 2024). However, Tsútswecw is best known for being the most significant remaining natural sockeye salmon spawning channel in North America, hosting the annual migration of 30 distinct sockeye runs (Ministry of Water, Land and Air Protection, 2002). Every fourth year during the dominant run, millions of sockeye salmon return to spawn, which is celebrated by the Salute to the Sockeye Festival (BC Parks, 2024). Although chinook, coho, and pink salmon also spawn in the Adams River, sockeye account for more than all other runs combined (Ministry of Water, Land and Air Protection, 2002).

Archaeological evidence of large, long-standing settlements, including fire-burned rock, basalt flakes, pictographs and over 300 cache pits, signify the area's historical importance for traditional spearfishing practices (Ministry of Water, Land and Air Protection, 2002). Formerly named Roderick Haig-Brown after the conservationist who worked to classify the park, it was renamed in 2018 to reflect the ancestral connections and given the traditional Secwepemc name "Tsútswecw" which translates to "many rivers" (BC Parks, 2024). For millennia, the Adams River sockeye have been central to the Secwepemc peoples of the Shuswap and Adams Lake

regions, whose core value, *kwseltknews* - meaning ‘we are all related’ – has guided their efforts to protect and sustain the salmon populations (The Adams River Salmon Society, n.d.).

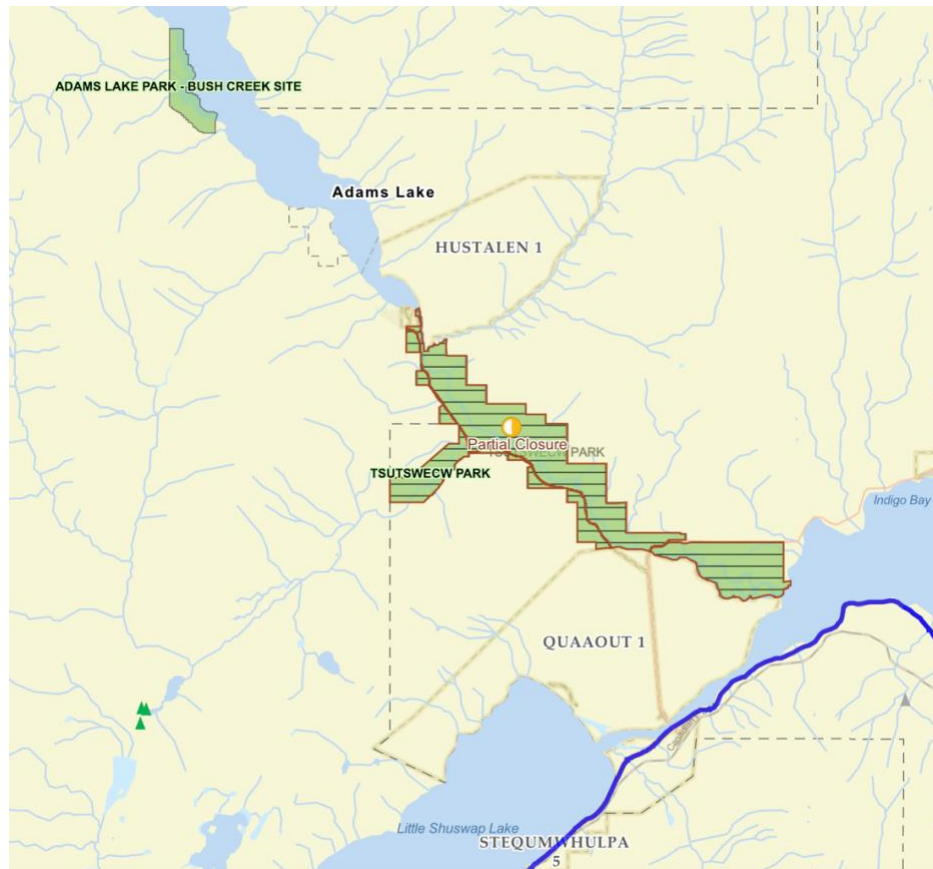


Figure 1 Map of the Tsútswecw Provincial Park in the North Shuswap Region

The productivity and abundance of anadromous sockeye are particularly sensitive to climate change, due to the vast number of climate-related stressors they are exposed to (Martins, et al. 2012). Adams River sockeye have a lower ability to tolerate significant acute stressors, showing signs of physiological stress and osmoregulatory impairment (Donaldson, et al. 2010). This was further emphasized when Donaldson et al. found that the Adams River sockeye had ~60% lower survival rates after the Thompson River confluence than Chilko sockeye, attributing it to the rising water temperatures during their late migration. The impact of high temperatures during adult migration and their ability to adapt to future climate change is of particular concern (Whitney, Hinch and Patterson, 2013), especially with extensive loss of suitable river-rearing habitat (Wood, et al. 2008) and the effect of fire-warming on life-history traits (Gomez Isaza, Cramp and Franklin, 2022).

Bush Creek East Fire (K21633)

Leading up to the 2023 fire season, BC had higher drought codes than normal in the fall due to daytime temperatures ranging four to ten degrees above normal and less precipitation than average (Government of British Columbia, 2025). The reduced moisture and elevated drought codes continued into the spring of 2023, paving the way for advanced fire conditions (Government of British Columbia, 2025). With only 20 – 60% of normal precipitation received, the province saw historically high temperatures in June and July and ten new records were set for warmest days (Government of British Columbia, 2025). The lack of moisture was accompanied by escalated lightning activity, with 51,000 lightning strikes recorded between July 7 – 13, which created 399 new wildfires ignited (Government of British Columbia, 2025). Among these fires were the Bush Creek East Fire (K21633) and the Lower East Adams Lake (K21620), both igniting on July 12th (Columbia Shuswap Regional District, 2024).

The battle to get the fires under control continued into August, where hot, dry conditions persisted, and a heatwave set 40 new temperature records between August 15 – 18 for the province (Government of British Columbia, 2025). Following this, a dry cold front influenced by Tropical Storm Hillary emerged and pushed winds between 40 to 60 km/hr for a 24-hour period (Columbia Shuswap Regional District, 2023; Government of British Columbia, 2025). This combination of intense heat and severe winds facilitated extreme fire behaviour and high rates of spread, resulting

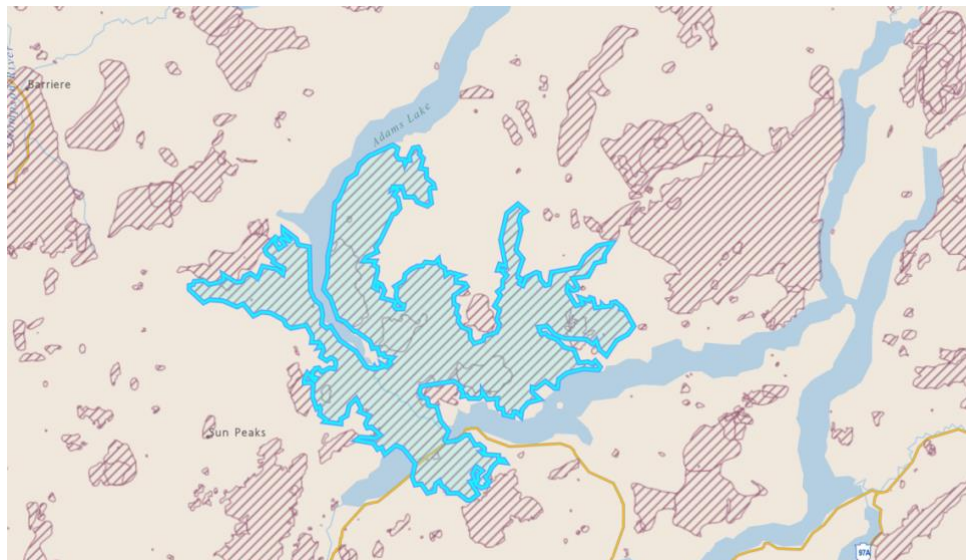


Figure 2 Map of the area burned by the Bush Creek East Fire (K21633) in 2023.

in the Bush Creek East Fire (K21633) and Lower East Adams Lake (K21620) merging and were subsequently referred to as Bush Creek East Fire (K21633) (Government of British Columbia, 2025). The severe winds caused the fire to sprint 20 kilometres on August 18 (Insurance Bureau of Canada, 2023), threatening eight communities in the Shuswap region, and forcing over 8,000 people to evacuate (Columbia Shuswap Regional District, 2024). Residents were able to return to the area on September 6 and found that the destructive fire resulted in 176 structures lost and 50 partial lost (Columbia Shuswap Regional District, 2024), accumulating over \$240 million in insured damages (Insurance Bureau of Canada, 2023). The Bush Creek East Fire (K21633) burnt a total of 45,613 hectares and was officially declared out on December 13 (BC Wildfire Service, 2023).

Impacts to Sockeye and their Spawning Habitat

A consulting company was hired by the Columbia Shuswap Region District to assess the region's geomorphology and identify areas at risk for post-fire debris flows or floods. Out of the 73 watersheds assessed, 10 zones of high risks were found (Columbia Shuswap Regional District, n.d.), including the Tsútswecw Park, where both sides of the Adams River had burned - though the highest burn severity occurred on the south side of the river (Columbia Shuswap Regional District, 2024). This loss of riparian vegetation has serious ecological implications. Increased solar radiation and altered temperature regimes are especially concerning (Bixby, et al. 2015) as they decrease dissolved oxygen levels, alter the toxicity of pollutants, impact trophic dynamics, and effect all stages of sockeye reproduction (Johnson, et al. 2024). In addition, warmer waters elevate metabolic stress and energetic costs of sockeye, especially under hypoxia conditions (Gomez Isaza, Cramp and Franklin, 2022). While hypoxia can result in mortality at all life stages, this is particularly worrisome for immobile sockeye eggs, which require more oxygen at higher temperatures and vary in sensitivity at different stages of embryo development (Crozier and Siegel, 2023). Furthermore, the loss of canopy cover reduces leaf litter inputs, increase predation rates, and reduces interception rates, leading to increased timing and rate of snowmelt, which can exacerbate the already existing drought impacts (Teclé and Neary, 2015; Ward, et al. 2022).

Degraded riparian zones reduces filtration of fine sediments from entering the river, and increases streambank instability, which can accelerated erosion rates and raise the risk of channel

restructuring (Ward, et al. 2022). The risk of sedimentation entering the river is amplified by the steep slopes of Nikwikwaia Creek, where severe burns have made slopes highly susceptible to post-fire debris flows that could deposit sediment and debris into Adams River, potentially causing aggradation in the mainstem (Columbia Shuswap Regional District, 2024). Additionally, post-fire hydrophobic soils further contribute to sediment and pollutant loading through surface runoff and wind transport (Teclé and Neary, 2015; Gomez Isaza, Cramp and Franklin, 2022). These inputs may include ash, high concentrations of mobilized nutrients, metals, polycyclic aromatic hydrocarbons (PAHs), and residual fire suppressants – many of which can be toxic to sockeye salmon (Ward, et al. 2022). The oxygen availability to embryos is further reduced by fine sediment deposits on redds (Crozier and Siegel, 2023). Together, these changes can significantly degrade water quality by reducing dissolved oxygen levels, promote algal growth, and fill in essential thermal refugia pools (Ward, et al. 2022). These stressors pose a serious threat to sockeye survival by increasing the risk of eutrophication, chemical exposure, disease outbreak and invasive species competition (Johnson, et al. 2024). Large scale, well-deigned restoration that can support a wide diversity of salmon life histories efforts and effectively mitigate long-term climate impacts should be prioritized to rebuild and maintain critical habitat (Crozier and Siegel, 2023), with an emphasis on riparian vegetation and thermal refugia zones.

The 2023 Bush Creek East Fire has enhanced the vulnerability of sockeye salmon and their spawning habitats in Tsútswecw Provincial Park. As climate change increases fire severity, impacts such as riparian vegetation loss, sedimentation, and warming waters threaten the delicate conditions that sockeye require to survive and reproduce, further adding to their population declines. Given these cumulative pressures, restoration of riparian zones, sediment controls, adequate forest management practices and a collaborative “walking with two legs” approach with the Secwepemc community are essential to support resiliency in these fire-affected ecosystems.

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