Fragmentation (Barrier Dams) and Bull Trout

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Species Information

Common Name: Bull Trout
Genus: Salvelinus confluentus

Stressor Details

Stressor Name: Fragmentation (large barrier dams)
Units: Unitless
Metric: Barrier Dam Effect Size
Scale: linear
Function Type: step
Vital Rate/Process: System capacity

Life Stage & Context

Life Stages: Adults
Geography: Alberta foothills watersheds, excluding National Parks
Activity: All activities
Season: All seasons

Descriptions

Overview

Dams can cause environmental changes such as alterations to water temperature, flow regime and sediment loading (Marmulla 2001). However, one of the most serious concerns for fish species is the fragmentation of connected riverine habitats, as dams that are not equipped with fish passage facilities can act as complete barriers to upstream and downstream fish movements (Marmulla 2001; GOA 2023, The Alberta Westslope Cutthroat Trout Recovery Team 2013). Many fish populations are likely sustained by metapopulation dynamics, where immigration from source populations ensures the persistence of surrounding subpopulations (Hanski 1998; Dunham and Rieman 1999). As a result, severing lotic connections may limit dispersal, and inhibit the recolonization of small, isolated populations that can be at increased risk of extinction through demographic, environmental and genetic stochasticity (Lande 1998; Morita et al. 2009). While literature has explored fragmentation of sturgeon habitat (Jager et al. 2001), fewer studies have evaluated the effects of dams on stream-dwelling salmonids. Of the available literature, Morita and Yokota (2002) found that extinction risk of White-Spotted Charr (Salvelinus leucomaenis) increased in small and isolated habitat fragments (Morita and Yamamoto 2002; Letcher et al. 2007). For cutthroat trout (Oncorhynchus clarkii), Harig and Fausch (2002) noted that population success upstream of barriers was strongly linked to available habitat area. Letcher et al. (2007) simulated fragmentation scenarios in a stream-resident Brook Trout (Salvelinus fontinalis) metapopulation and found that extinction was likely unless immigration from above barriers was possible or fish exhibited demographic life history changes.

In Alberta, it is difficult to quantify the effects of fragmentation due to large dams on the native trout species. The overall population level effect depends on a variety of factors such as patch size, habitat quality, and population size (Morita et al. 2009), as well as life history and behavioural traits (Letcher et al. 2007, Morita et al. 2009) and meta-population dynamics, and in most cases this information is not available for fish populations in the province. It is possible however, to provide a relative, qualitative estimate based on professional opinion considering available datasets. Several hypothetical situations will be described to elucidate this process. In the simplest case, if there are no dams in the system, then there is no effect. If a dam inhibits movement of migratory Bull Trout into a small portion of the lower watershed they once occasionally frequented (based on telemetry data), a low or very low effect size may be assigned. In contrast, a moderate effect would be assigned if the dam resulted in an isolated, trout population existing in a relatively small habitat patch, with no possible connections to other trout populations. Lastly, the severe decline or functional extirpation of migratory trout downstream of

a dam soon after construction may indicate that suitable habitat to support all life history needs is no longer available (high to very high effect size). Until further information is available, the relationship between barrier dam effect size and sustainability of trout populations is assumed to be linear (Figure 1).

Function Derivation

Expert Opinion; Based on data from Bull Trout

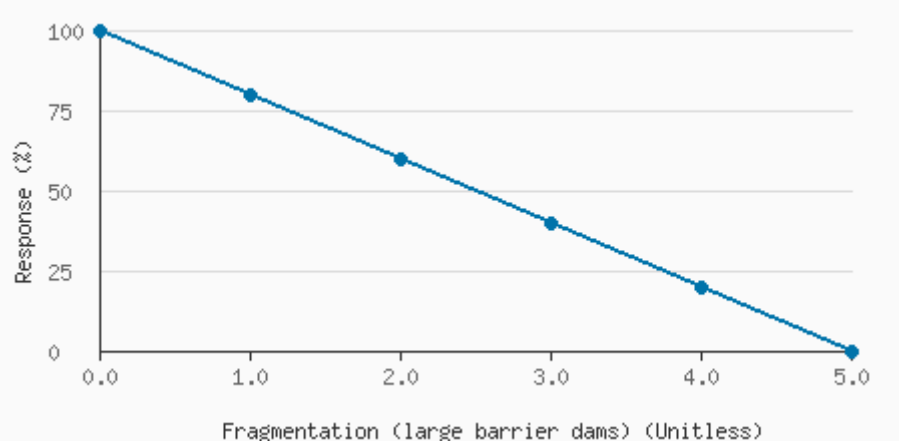
Transferability of Function

This function was developed and applied to Bull Trout, Athabasca Rainbow Trout, and Westslope Cutthroat Trout in Alberta foothills watersheds. While fragmentation due to large barrier dams has been shown to influence many aquatic systems, this function should be applied to other species and systems with caution.

Source of Stressor Data

Qualitative estimate of barrier dam effect, based on expert opinion considering available data on trout movement, abundance, presence of life history type and change to trout populations before and after dam construction.

Stressor Response Data



Barrier Dams (#)	Mean System Capacity (%)	SD	low.limit	up.limit
0	100	0	0	100
1	80	0	0	100
2	60	0	0	100
3	40	0	0	100
4	20	0	0	100
5	0	0	0	100

Citations

Government of Alberta. 2024. Fragmentation (large barrier dams) stressor-response function for Athabasca Rainbow Trout, Westslope Cutthroat Trout, and Bull Trout. Environment and Protected Area Native Trout Cumulative Effects Model.

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