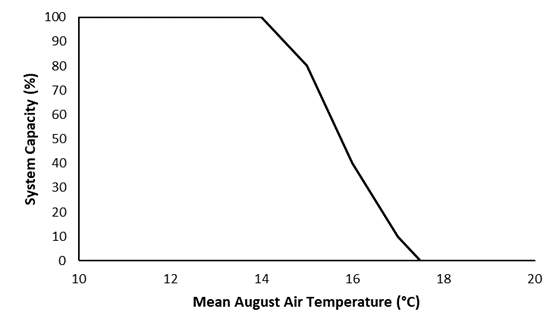
# Summary: Summer Temperature and System Capacity



# Stressor**:** Temperature (mean August

air temperature (oC))

# Response: System Capacity (%)

# Species: Bull Trout

# (*Salvelinus confluentus*)

# Life Stage: adult

# System: Alberta foothills watersheds, excluding National Parks

# Function Derivation: landscape correlation, peer-reviewed observational data

# Transferability of Function: This function was developed and applied to Bull Trout in Alberta foothills watersheds. The data comes from landscape correlation with Alberta Bull Trout streams and is supported by values in the published literature. The function is species specific but could be applied to other Bull Trout populations that are limited by high temperatures (the minimum temperature range is undefined) with caution.

# Model Validation: Model not validated on independent data.

# Detailed SR Function Description

## Derivation of the function:

## Each of the three native trout species are thermally sensitive and vulnerable to increased water temperature resulting from land disturbance and climate change (GOA 2023; Alberta Athabasca Rainbow Trout Recovery Team 2014; The Westslope Cutthroat Trout Recovery Team 2013).

## The thermal characteristics of Bull Trout habitat in Alberta were explored by comparing mean warmest month temperature (MWMT) derived using the program Climate WNA© (Hamann and Wang 2005; Wang et al. 2006) to all locations where Bull Trout have been captured between 1946–2013 (FWMIS query, Nov. 2013). Air temperature was used in this analysis because there is currently no province-wide water temperature dataset or model available. Of note, updated spatial stream network (SSN) temperature models are currently in development, but were not yet complete for use in this version of the Joe model. We expect that refinements to the stream temperature model stressor-response curves and watershed input values will occur once these models are complete. In addition, air and water temperatures are typically correlated over time scales >1 week (Mohseni et al. 1998). The minimum and maximum air temperature thresholds (10°C and 17°C; Figure 1) were similar to those reported in previous laboratory and field studies investigating the effects of water temperature on Bull Trout growth and survival (Selong et al. 2001) and occupancy (Dunham et al. 2003; Wenger et al. 2011). The findings of this analysis were used to inform the shape of the stressor-response curve below, which characterizes the expected influence of warm temperatures on the system capacity of Bull Trout populations (Figure 1).

## The rapid decline in the number of occurrences of the three trout species on the colder ranges, between 10°C to 13°C for Bull Trout, 6°C to 8°C for Athabasca Rainbow Trout and 8°C to 13°C for Westslope Cutthroat Trout is likely due to sampling bias (i.e., there are fewer sampling events in cold, high-elevation areas that are difficult to access). However, in visually inspecting stream temperatures in colonized Jasper National Park streams with excellent Athabasca Rainbow Trout populations they fall within the modelled 5-8°C temperature range. Therefore, lotic habitats with these colder temperatures were still considered to be excellent Athabasca Rainbow Trout habitat and while cold temperatures undoubtedly can limit Bull Trout and Westslope Cutthroat Trout distributions, for the first iteration of this dose-response curve the results were not extended to the cold side of the curve due to lower confidence in this portion of the analysis.

## Source of stressor data to apply the function:

# For Bull Trout, the mean August air temperature (°C) provided by ALCES Online© within the spatial unit of interest was used. Mean August air temperature (from ALCES Online©) and MWMT (from ClimateWNA) are expected to be highly correlated because the highest air temperatures in Alberta typically occur in August. Athabasca Rainbow Trout and Westslope Cutthroat Trout inputs were derived from modelled mean summer stream temperature (°C) provided by ALCES Online© within the spatial unit of interest (e.g., HUC 10 watershed).

# A graph showing the temperature of a person Description automatically generatedStressor-Response Function

**Figure 1:** Stressor-response curve informed using thermal range data for Bull Trout. The function depicts the expected relationship between high temperatures and system capacity, but the potential influence of cold temperature is not included in this curve.

Stressor-Response Table

**Table 1:** Stressor response relationship reflecting mean August air temperature (oC) within a watershed and the system capacity of Bull Trout populations.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MAAT (oC)** | **System Capacity (%)** | **SD** | **Lower Limit** | **Upper Limit** |
| 10 | 100 | 0 | 0 | 100 |
| 11 | 100 | 0 | 0 | 100 |
| 12 | 100 | 0 | 0 | 100 |
| 13 | 100 | 0 | 0 | 100 |
| 14 | 100 | 0 | 0 | 100 |
| 15 | 80 | 0 | 0 | 100 |
| 16 | 40 | 0 | 0 | 100 |
| 17 | 10 | 0 | 0 | 100 |
| 17.5 | 0 | 0 | 0 | 100 |
| 18 | 0 | 0 | 0 | 100 |
| 19 | 0 | 0 | 0 | 100 |
| 20 | 0 | 0 | 0 | 100 |
|  |  |  |  |  |
|  |  |  |  |  |

# SR Function Confidence and Sources of Uncertainty

This uncertainty rubric was populated based on a summary report, not by the authors of the function with the original data. These rankings should be reassessed if additional information is available.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Low Confidence** | **Moderate Confidence** | **High Confidence** |
| **Data Source for SR Function** |  |  | **X** |
| Rationale --> | The function was based on broad landscape correlation of air temperature with Bull Trout occupancy, supported by peer-reviewed temperature thresholds. | | |
| **Shape of SR Function** |  | **X** |  |
| Rationale --> | The upper limit of the function has high support, but the lower temperature threshold could not be determined with the existing data. | | |
| **Data Variance/**  **Consistency** | **X** |  |  |
| Rationale --> | Variance around this function is largely unknown. | | |
| **Applicability to System** |  |  | **X** |
| Rationale --> | This function was based directly on local landscape data, on the species of interest. | | |
| **Potential Stressor Interactions** | **X** |  |  |
| Rationale --> | As the function is based on landscape correlation, there is significant potential for stressors that covary with temperature to drive the relationship. For this reason, the lower threshold could not be determined because of low temperature correlation with areas that were not sampled. | | |

# Recommended Citation

This document should be cited as:

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