Evaluating the vulnerability of freshwater fish habitats to the effects of climate change in the Cariboo-Chilcotin:
Part II – Summary of results

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1.0 Introduction

This report presents results from an assessment of vulnerability of freshwater habitat in the Cariboo-Chilcotin to the effects of climate change, the methods of which are summarized in a separate document[1]. Section 2.0 Spatial extent – provides maps of distribution of bull trout, Chinook salmon, and coho salmon modeled throughout the study area (*Section 2.1*), and the spatial boundaries delineating alternative ways of distinguishing among population groups (*Section 2.2*) – watersheds (for bull trout and coho), salmon Conservation Units (for Chinook and coho), and sub-populations (for coho). Section 3.0 Stream flows – provides a map of the stream "nodes" at which flow predictions were available and broad-scale illustrations of historic (1961-1990) and future (2020s, 2050s, and 2080s) conditions (*Section 3.1*). Past conditions represent the "base" case for comparison and future conditions are represented by "best" and "worst" case outcomes across six modeled futures. Stream flows are measured by summer low flows for rearing (*Section 3.2*), and summer-fall bypass flows for spawning (*Section 3.3*) across 18 locations. Section 4.0 Stream temperatures – similarly provides a broad-scale illustration of the historic (1961-1990) and future (2020s, 2050s, and 2080s) stream temperature conditions as represented by the annual maximum of a 7-day moving average water temperature (*Section 4.1*). Thermal habitats are summarized in terms of their suitability for bull trout (*Section 4.2*), Chinook salmon (*Section 4.3*), and coho salmon (*Section 4.4*) using the species distribution layers and boundaries for population groupings as presented in *Section 2.0*.

2.0 Spatial extent

2.1 Species distributions

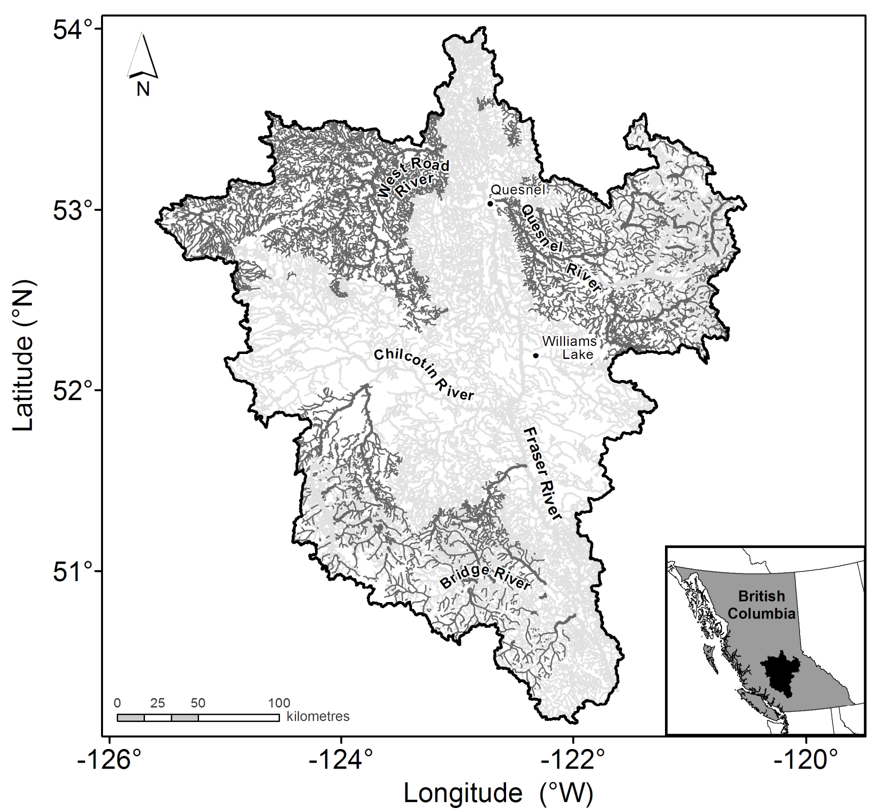

Figure 1. Baseline distribution of bull trout in the Cariboo-Chilcotin study area. Suitable reaches for bull trout habitats are dark grey, those not suitable are light grey.

[1] Nelitz, M., M. Porter, K. Bennett, A. Werner, K. Bryan, F. Poulsen, and D. Carr. 2009. Evaluating the vulnerability of freshwater fish habitats to the effects of climate change in the Cariboo-Chilcotin: Part I – Summary of methods. Report prepared by ESSA Technologies Ltd. and Pacific Climate Impacts Consortium for Fraser Salmon and Watersheds Program, B.C. Ministry of Environment, and Pacific Fisheries Resource Conservation Council.

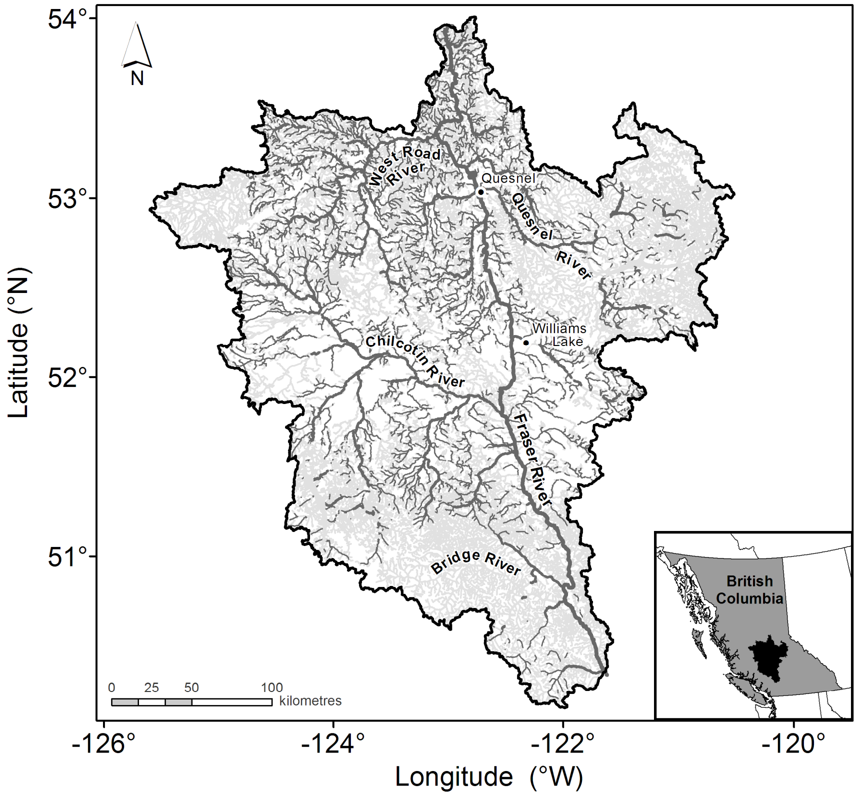

Figure 2. Baseline distribution of Chinook salmon in the Cariboo-Chilcotin study area. Suitable reaches for Chinook salmon habitats are dark grey, those not suitable are light grey.

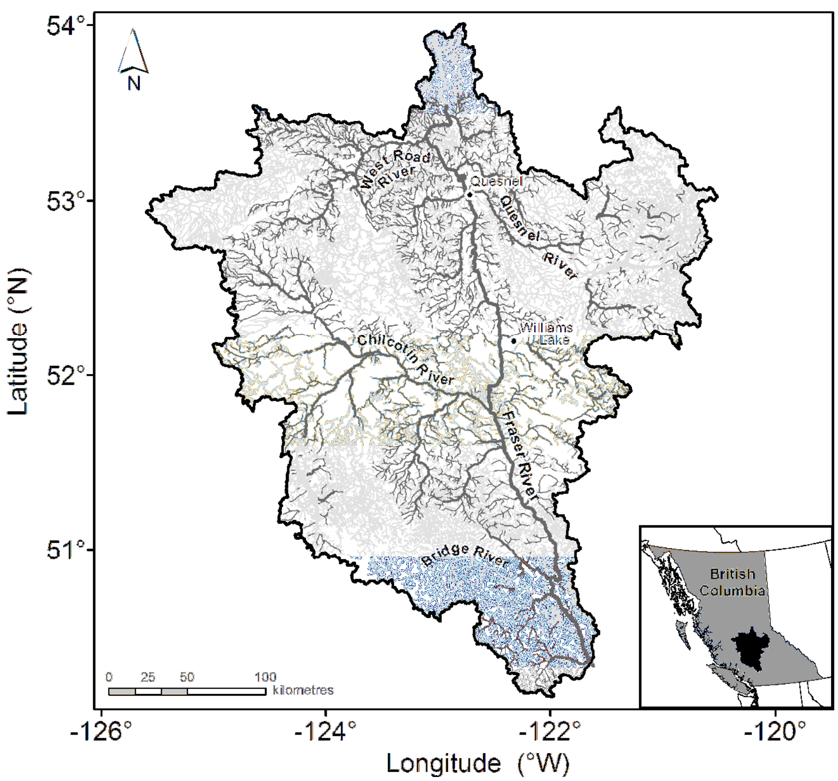

Figure 3. Baseline distribution of coho salmon in the Cariboo-Chilcotin study area. Suitable reaches for coho salmon habitats are dark grey, those not suitable are light grey.

2.2 Population delineations

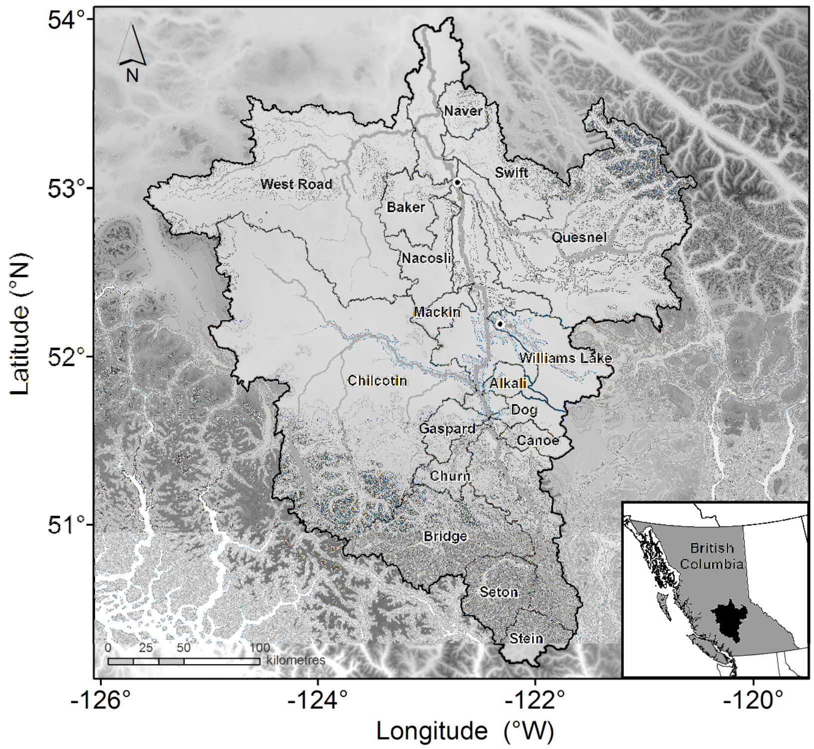

Figure 4. Watershed boundaries for all fourth order or higher drainages draining into the Fraser River. Used to summarize thermal habitats for bull trout and coho salmon.

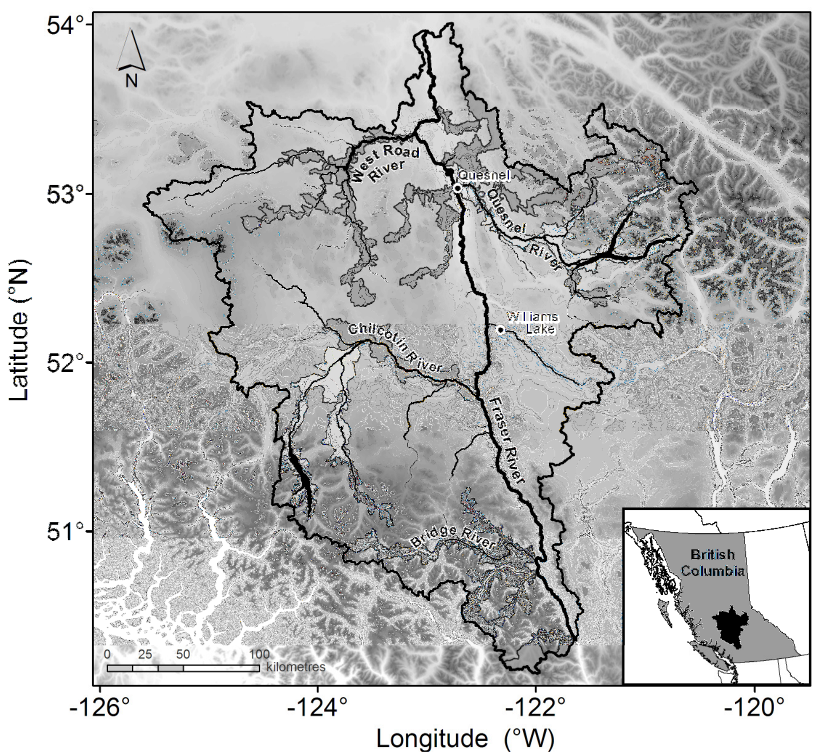

Figure 5. Spatial boundaries of Conservation Units for Chinook salmon in the Cariboo-Chilcotin – Middle Fraser, spring timing CU in dark shading, Middle Fraser, summer timing in light shading, Middle Fraser, Portage too small to be shown (CUs from Holtby and Ciruna 2007).

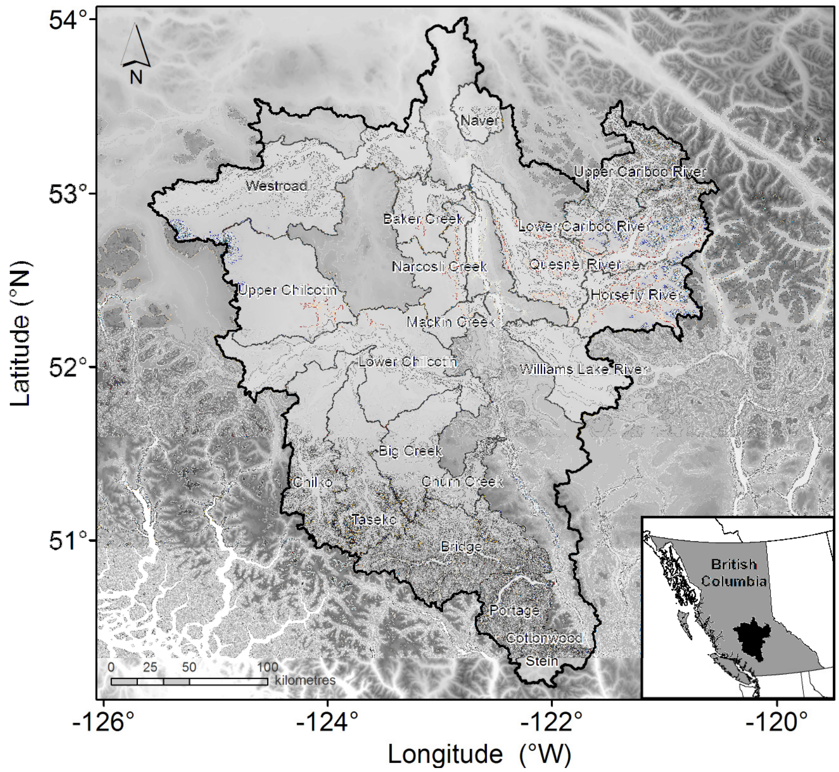

Figure 6. Spatial boundaries of draft stock units for Chinook salmon in the Cariboo-Chilcotin (C. Parken, DFO, pers. comm.).

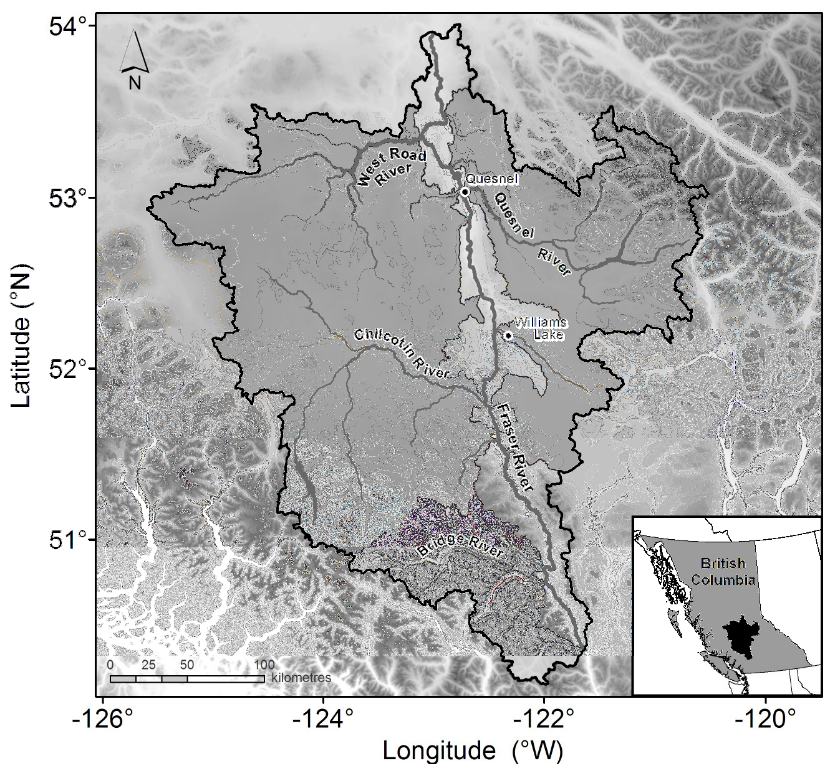

Figure 7. Spatial boundaries for sub-populations within the Upper Fraser population of Interior Fraser coho salmon – Middle Upper Fraser sub-population delineated as light shading, Upper Upper Fraser sub-population delineated as dark shading. The Middle Fraser Conservation Unit includes both of these sub-populations (Holtby and Ciruna 2007).

3.0 Stream flows

3.1 Historic (1961-1990) and future (2020s, 2050s, and 2080s) conditions

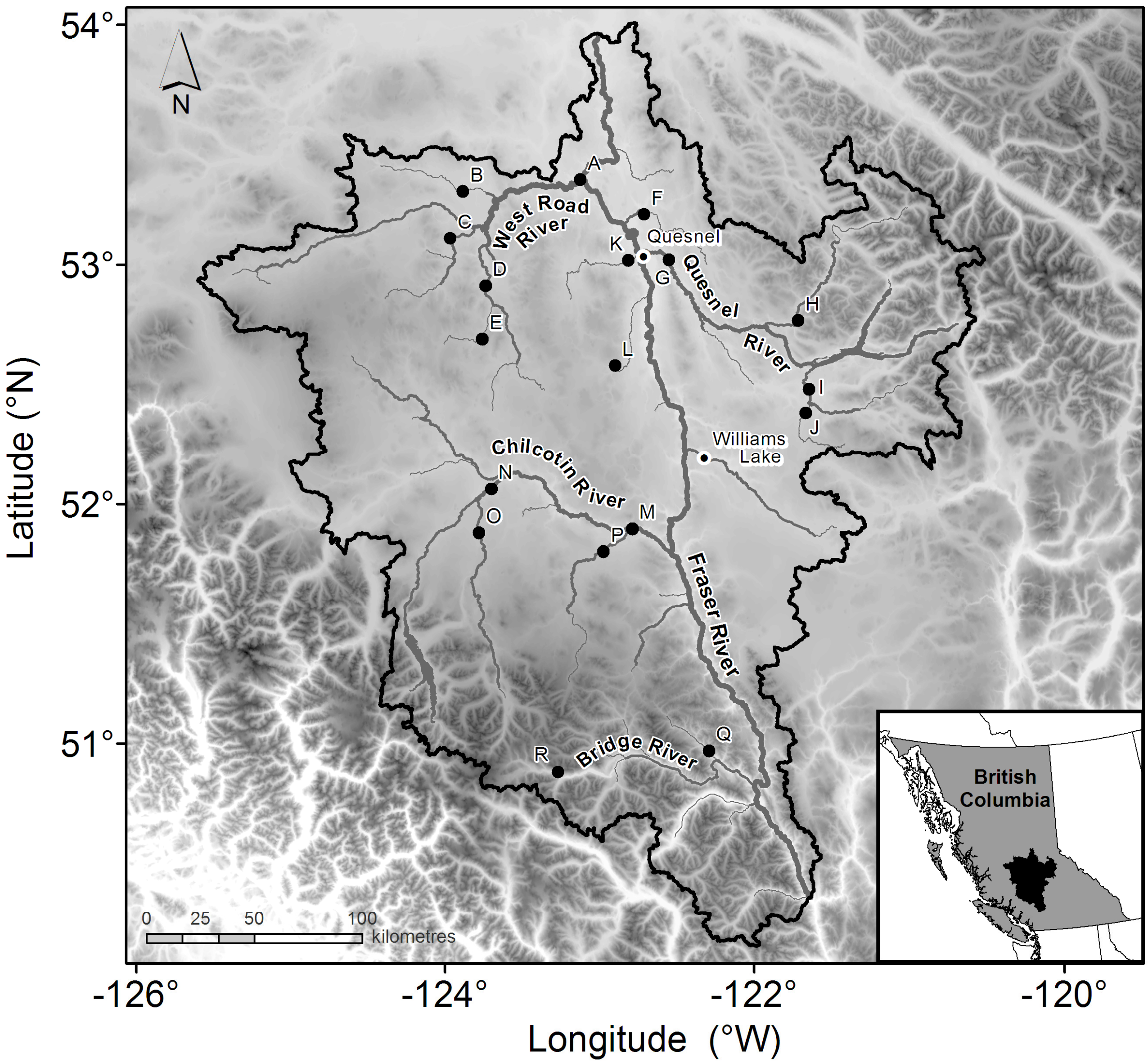

Figure 8. Spatial orientation of "nodes" at which flow data were summarized across the study area. Flow results in *Sections 3.2 and 3.3* present data from these "nodes".

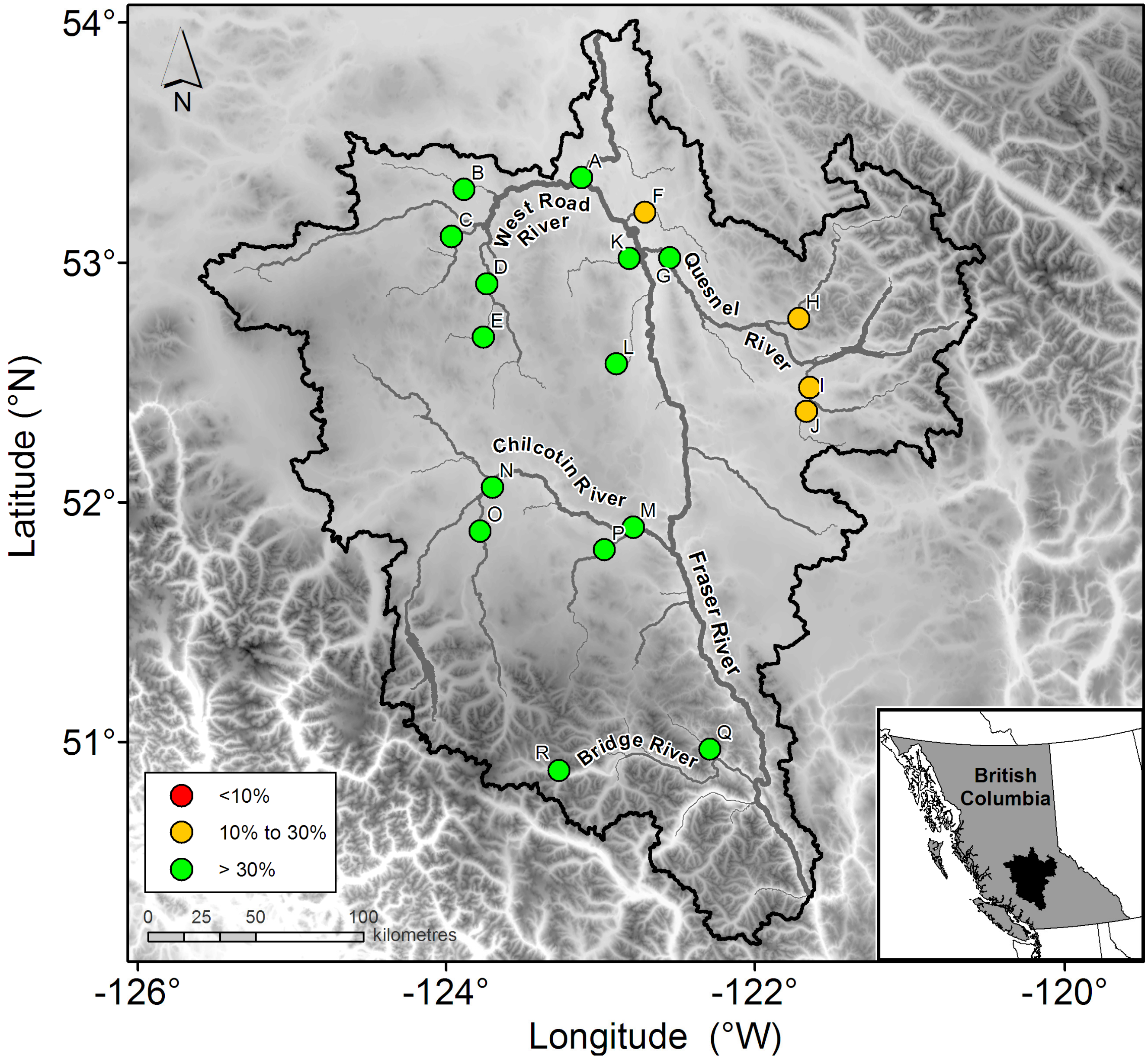

Figure 9. Minimum flow of a 7-day rolling average between July 1 and October 1 as a percentage of Mean Annual Discharge, calculated across 18 flow nodes for a historic reference period (1961-1990).

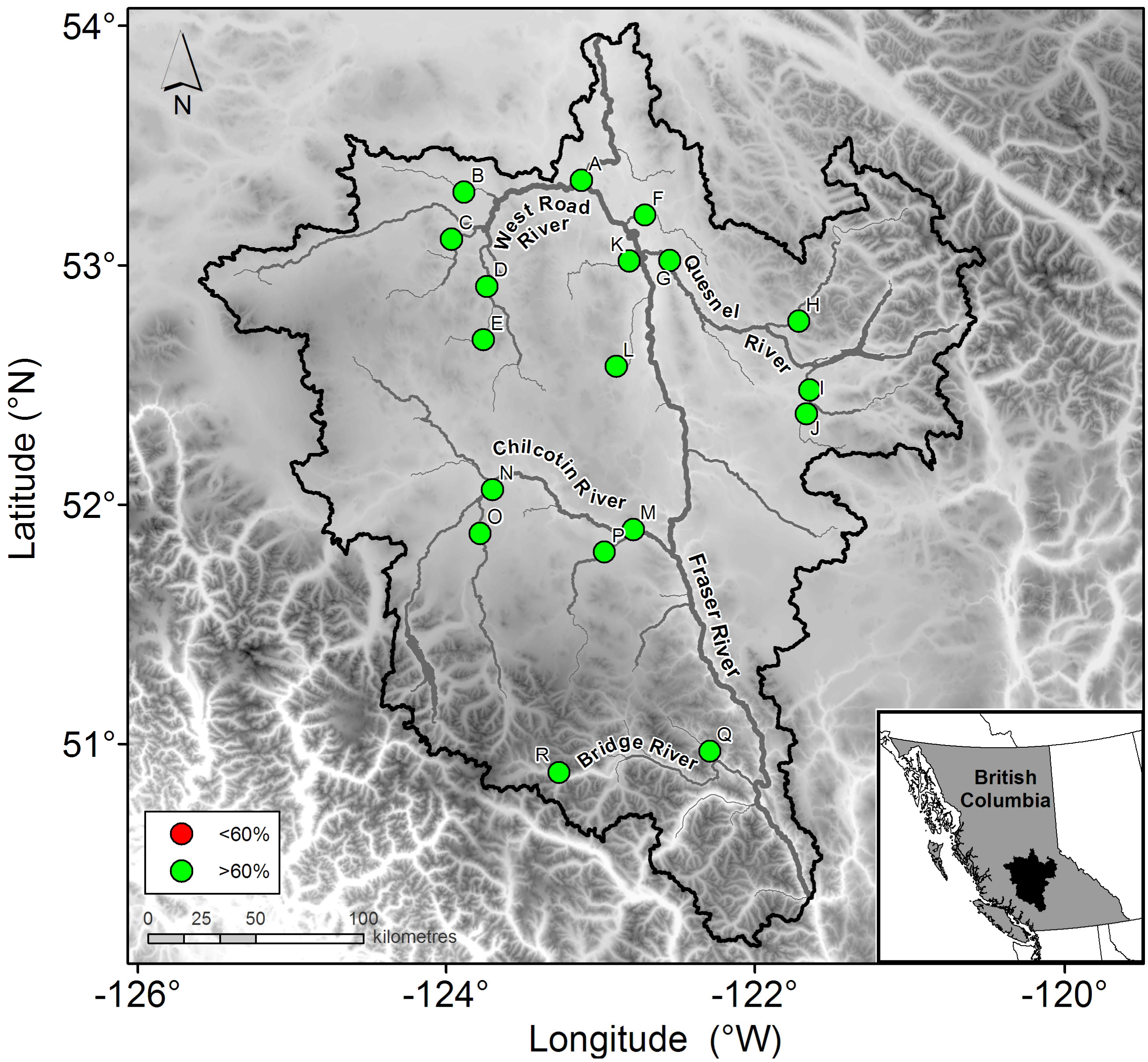

Figure 10. Maximum flow of a 7-day rolling average between July 15 and October 15 as a percentage of Mean Annual Discharge, calculated across 18 flow nodes for a historic reference period (1961-1990).

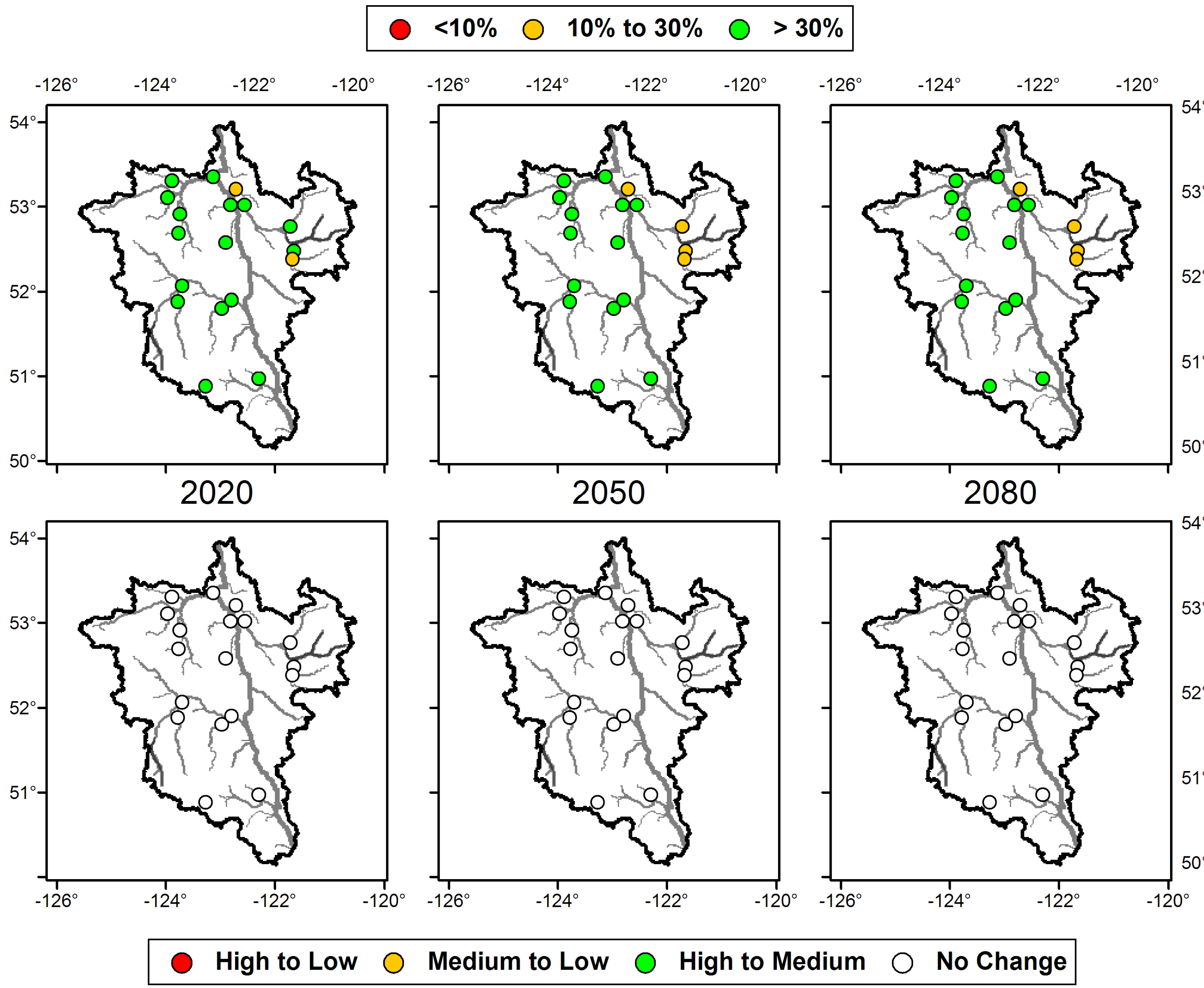

Figure 11. "Best" case outcome (i.e., least change in low flows) out of six climate change scenarios. Top panel represents locations with low flow concerns at three time periods (2020s, 2050s, 2080s), while the bottom panel represents changes from baseline predictions in Figure 9.

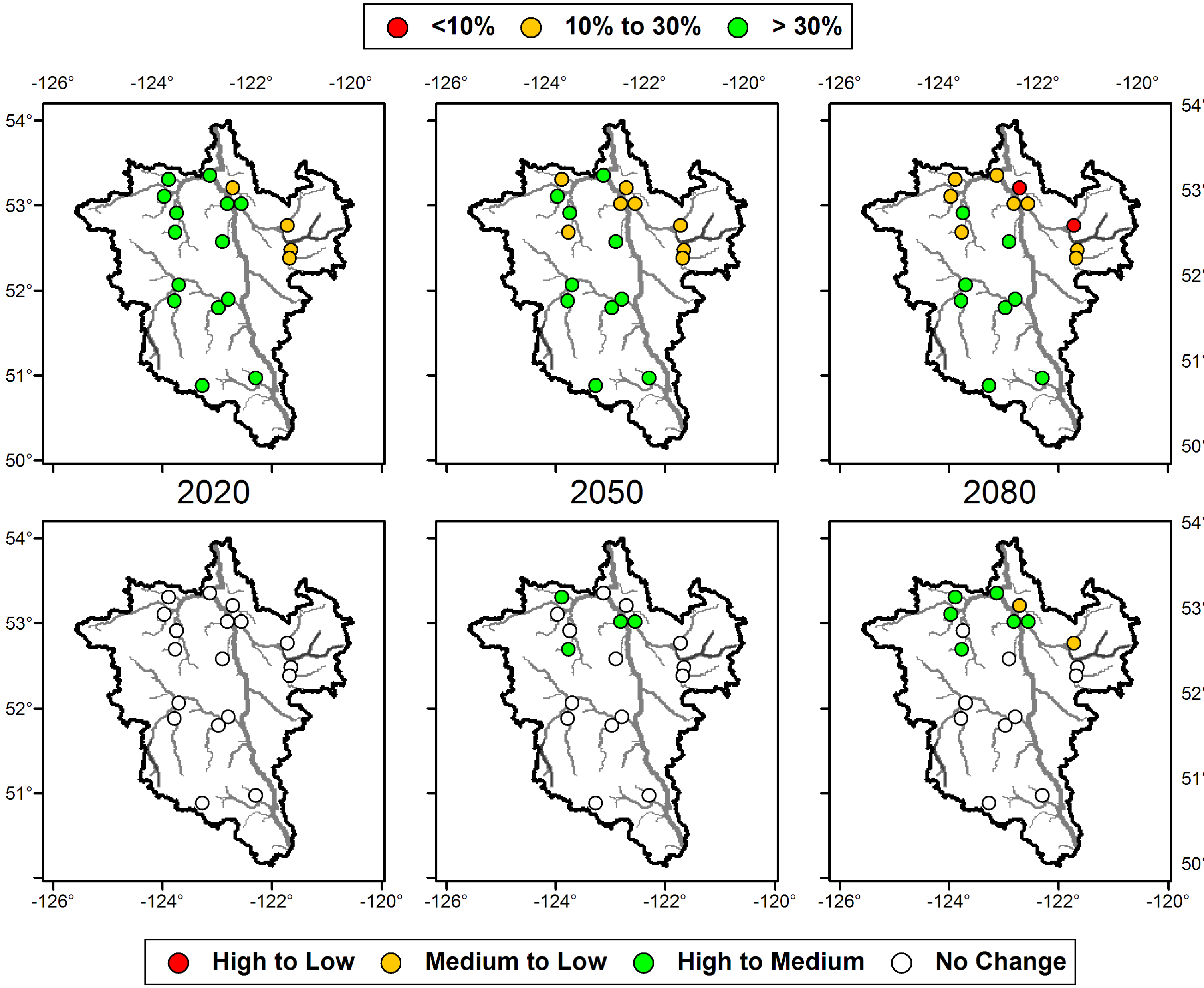

Figure 12. "Worst" case outcome (i.e., greatest change in low flows) out of six climate change scenarios. Top panel represents locations with low flow concerns at three time periods (2020s, 2050s, 2080s), while the bottom panel represents changes from baseline predictions in Figure 9.

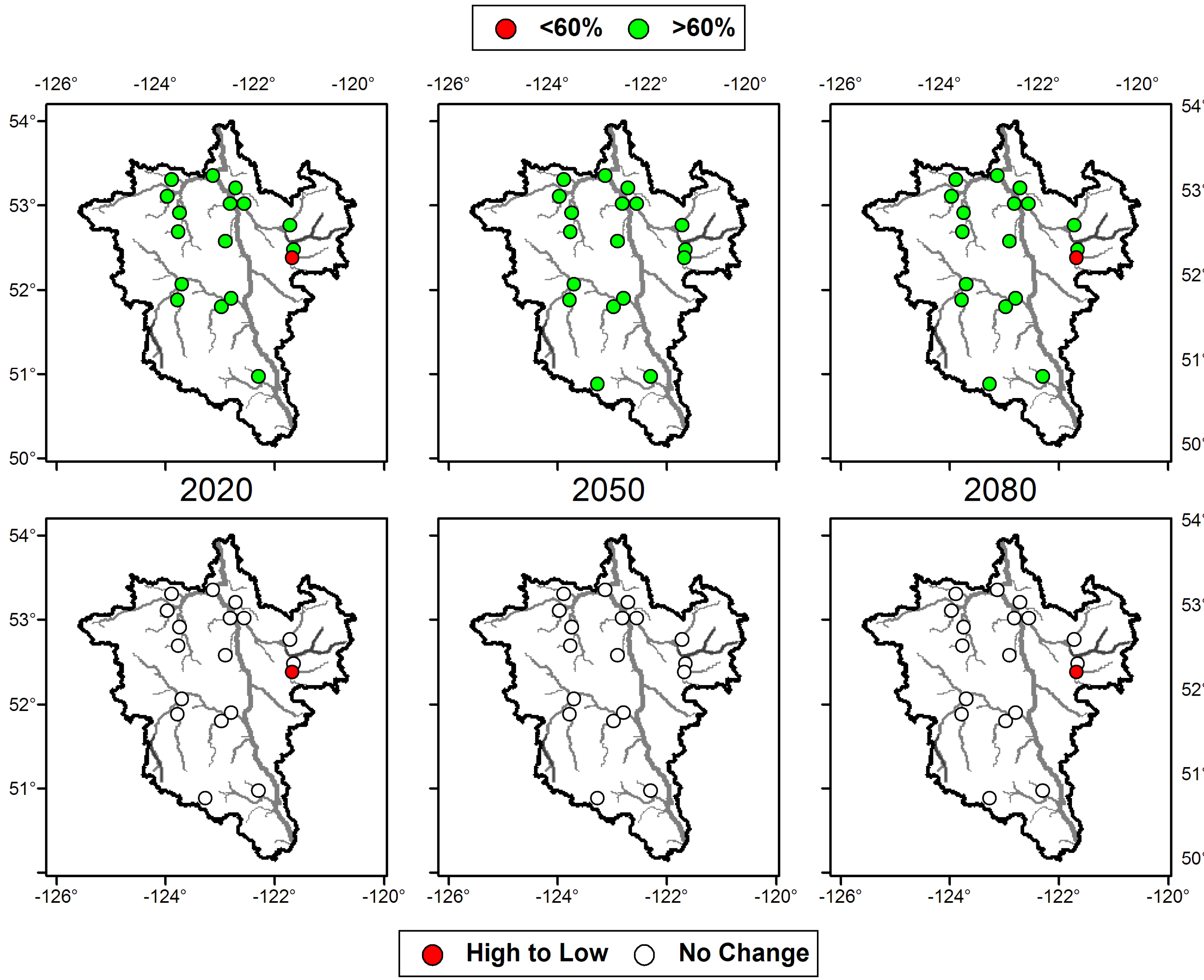

Figure 13. "Best" case outcome (i.e., least change in bypass flows) out of six climate change scenarios. Top panel represents locations with bypass flow concerns at three time periods (2020s, 2050s, 2080s), while the bottom panel represents changes from baseline predictions in Figure 10.

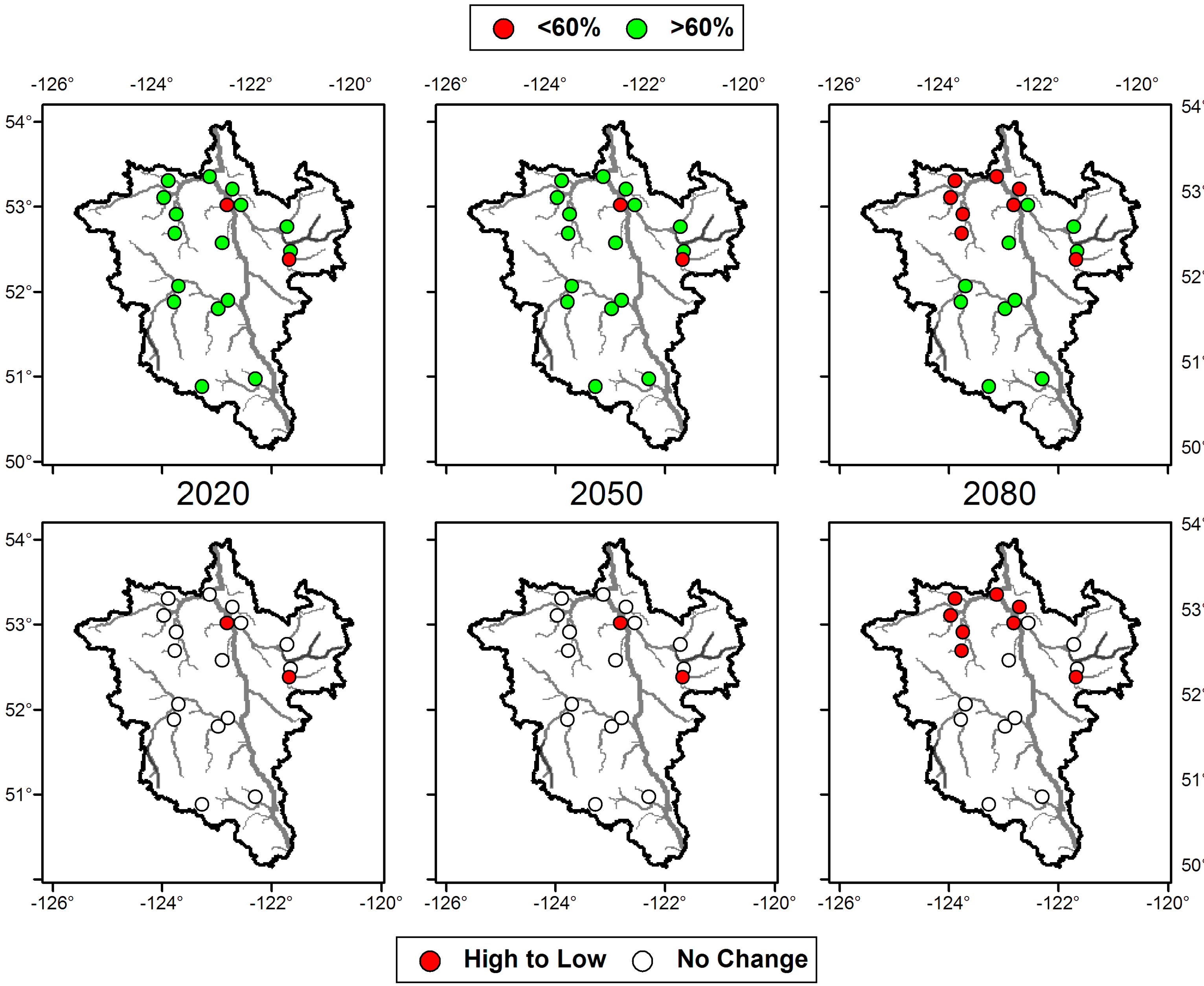

Figure 14. "Worst" case outcome (i.e., greatest change in bypass flows) out of six climate change scenarios. Top panel represents locations with bypass flow concerns at three time periods (2020s, 2050s, 2080s), while the bottom panel represents changes from baseline predictions in Figure 10.

3.2 Suitability of low flows for rearing

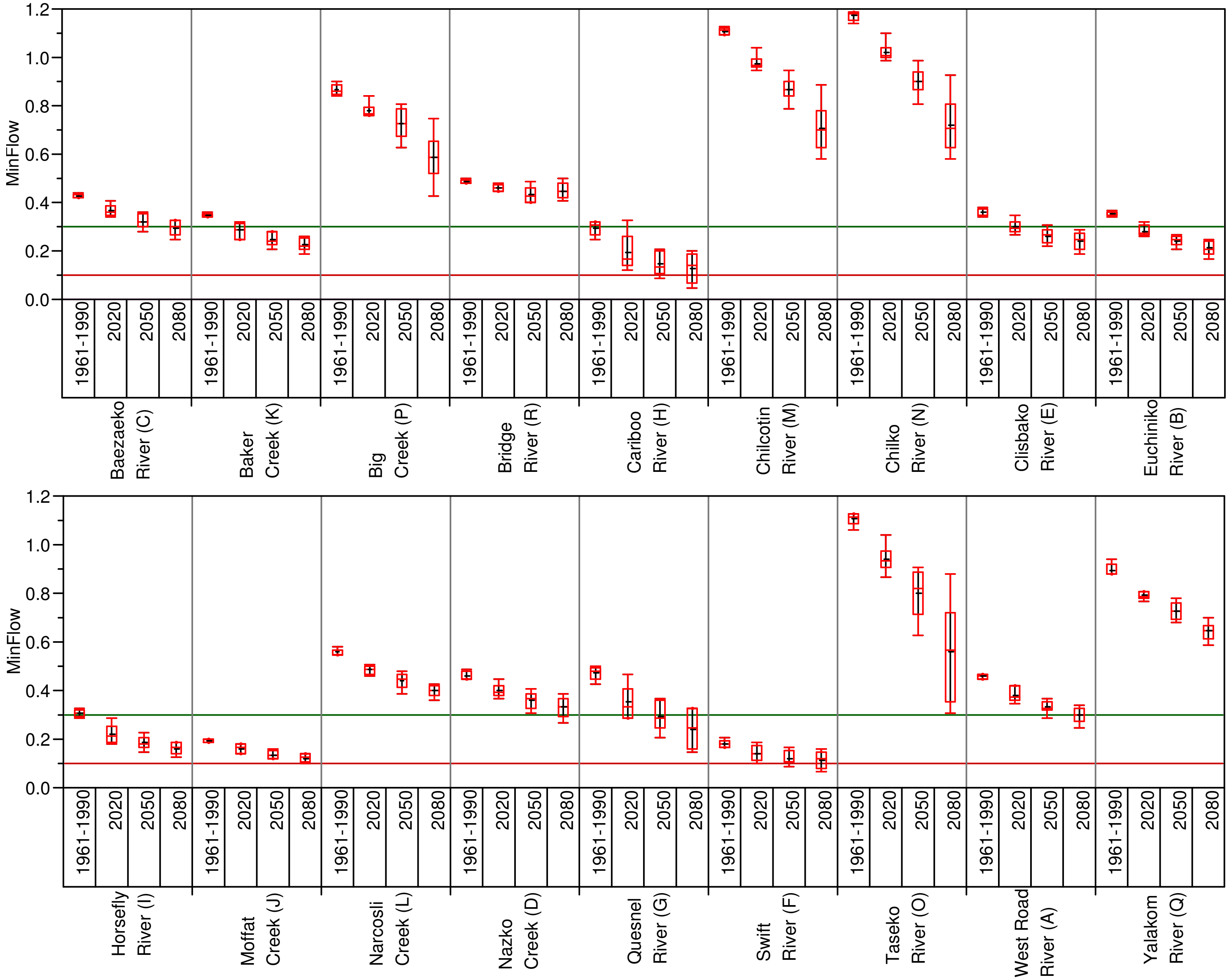

Figure 15. Minimum flow of a 7-day rolling average between July 1 and October 1 as a percentage of Mean Annual Discharge for historic and future time periods.

3.3 Suitability of bypass flows for spawning

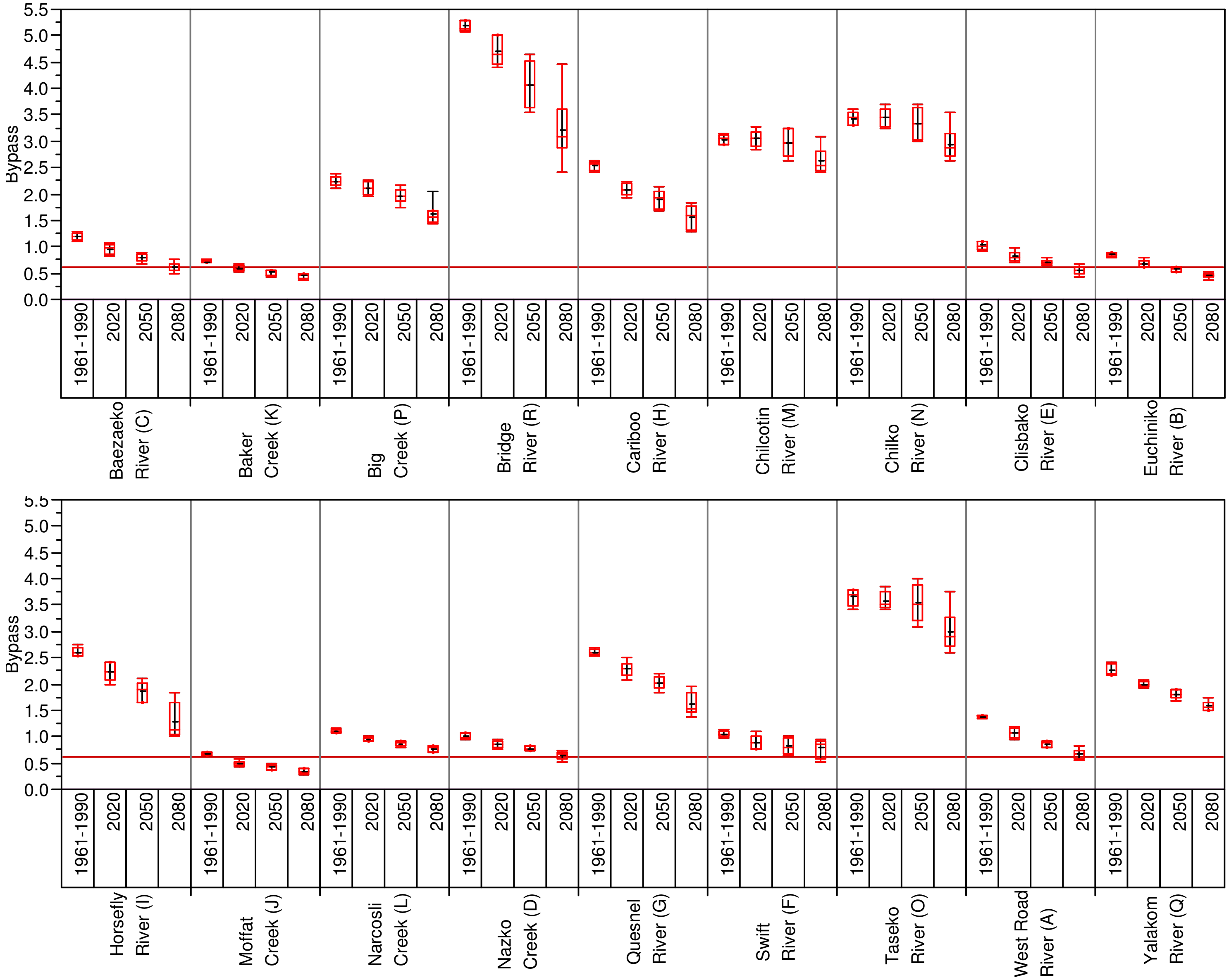

Figure 16. Maximum flow of a 7-day rolling average between July 15 and October 15 as a percentage of Mean Annual Discharge for historic and future time periods.

4.0 Stream temperatures

4.1 Historic (1961-1990) and future (2020s, 2050s, and 2080s) conditions

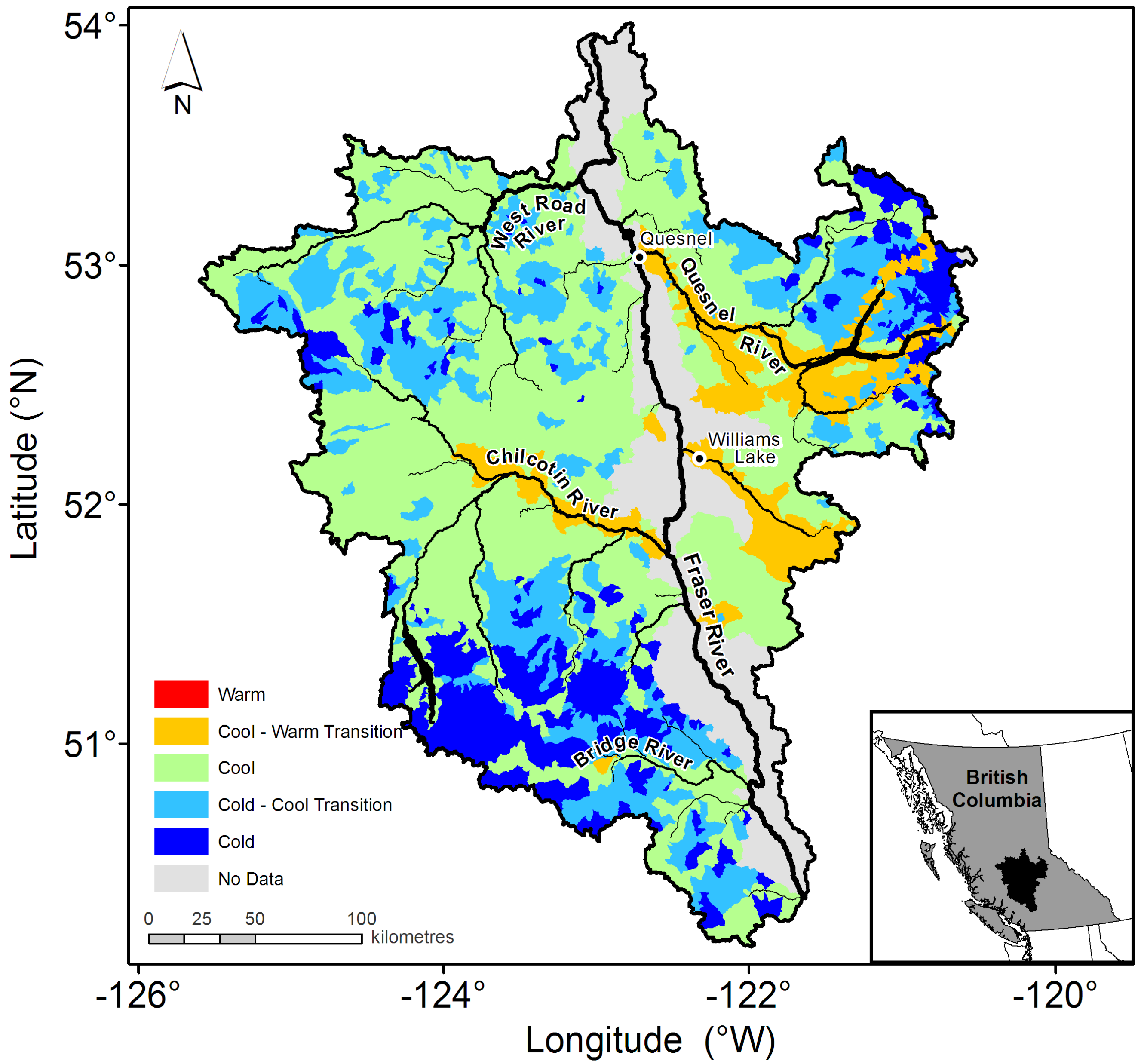

Figure 17. Predicted thermal classes for a historic reference period (1961-1990) for third order and larger basins across the Cariboo-Chilcotin study area.

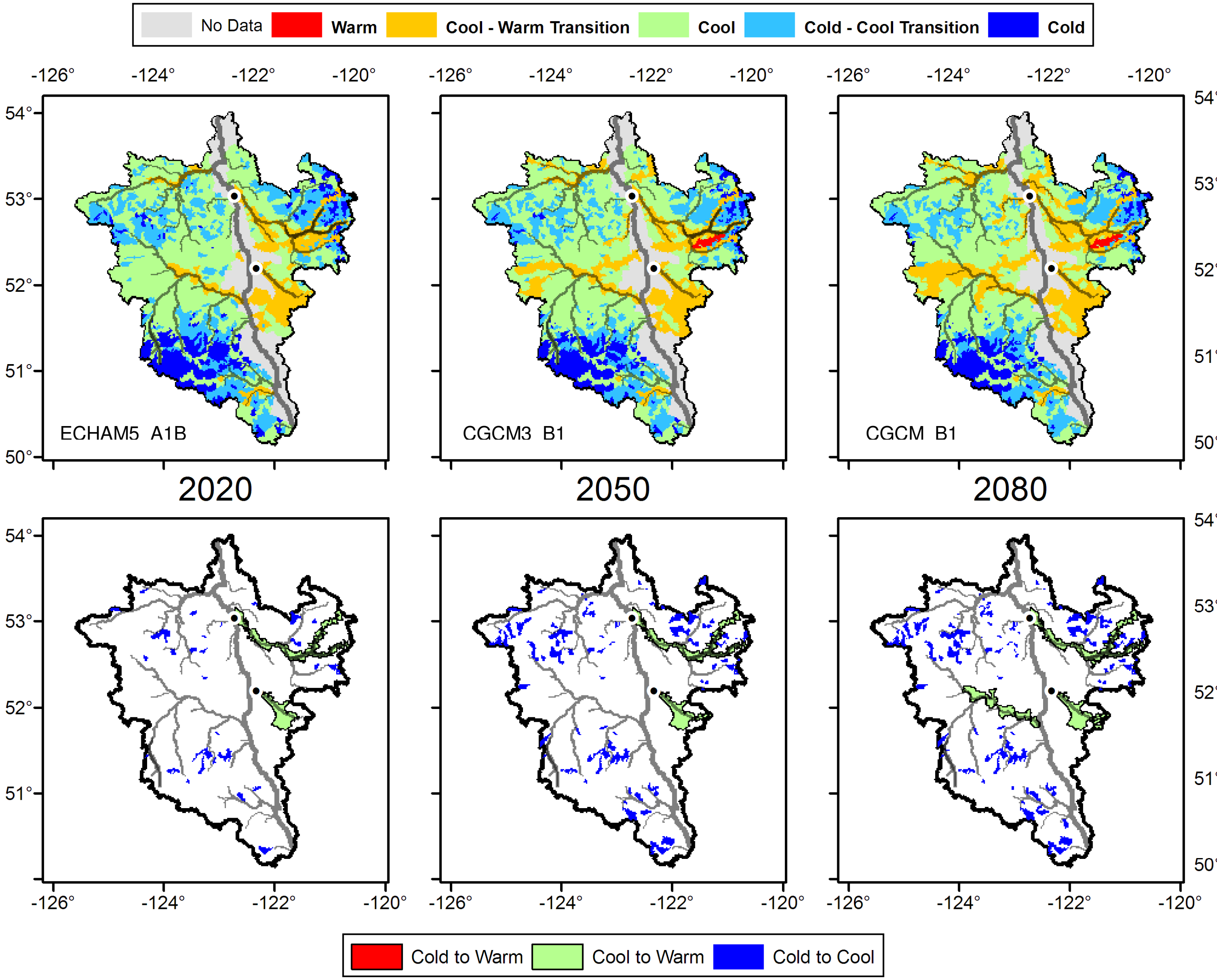

Figure 18. "Best" case outcome (i.e., least change in thermal classes) out of six climate change scenarios. Top panel represents predicted thermal classes over three time periods (2020s, 2050s, 2080s), while the bottom panel represents shifts in thermal classes (as noted by legend) from baseline predictions in Figure 17.

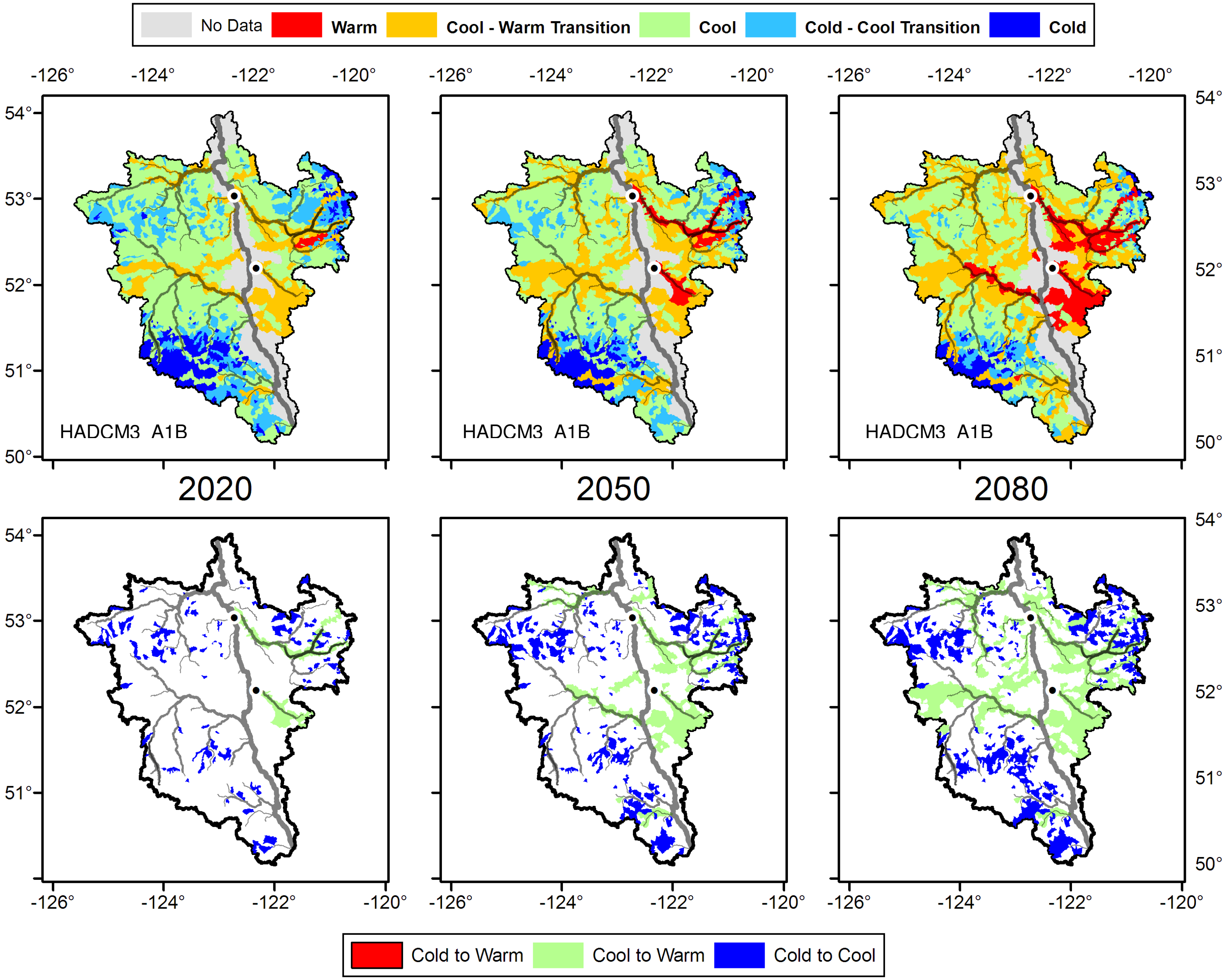

Figure 19. "Worst" case outcome (i.e., most change in thermal classes) out of six climate change scenarios. Top panel represents predicted thermal classes over three time periods (2020s, 2050s, 2080s), while the bottom panel represents shifts in thermal classes (as noted by legend) from baseline predictions in Figure 11.

4.2 Suitability for bull trout

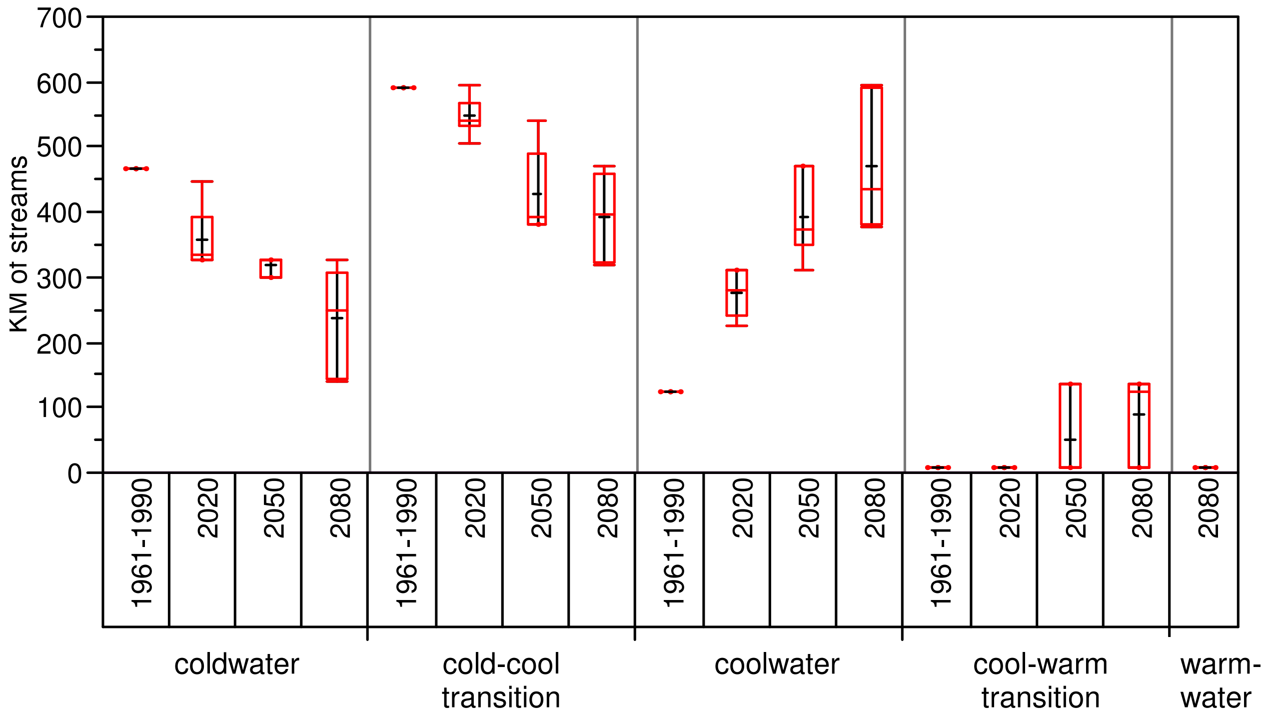

Figure 20. Linear extent (km) of thermal habitat classes across **Bridge River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

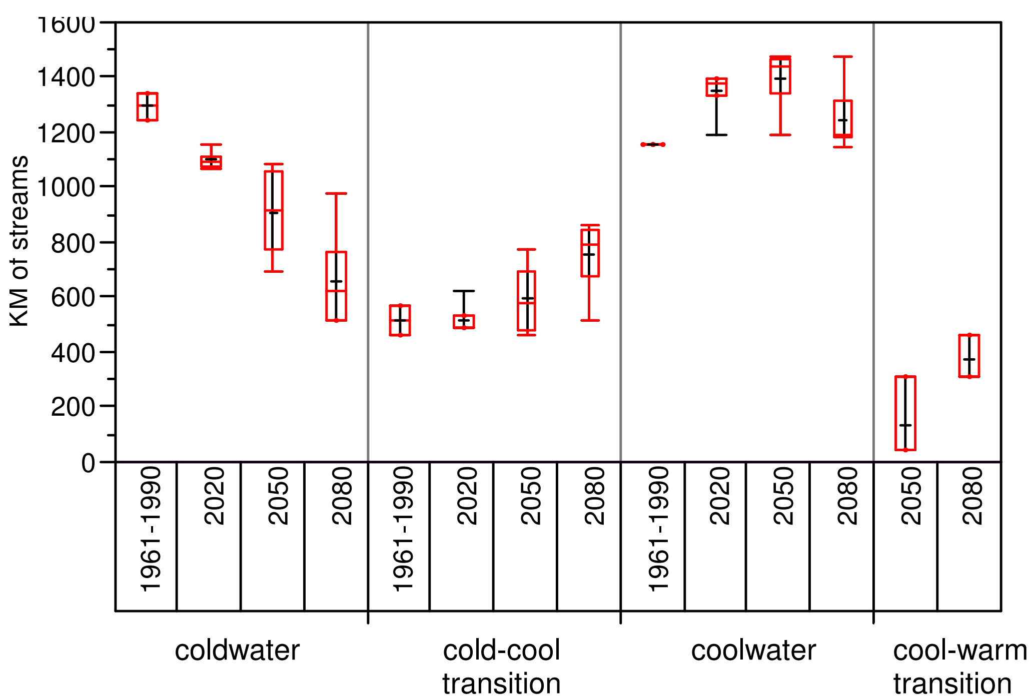

Figure 21. Linear extent (km) of thermal habitats across **Chilcotin River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

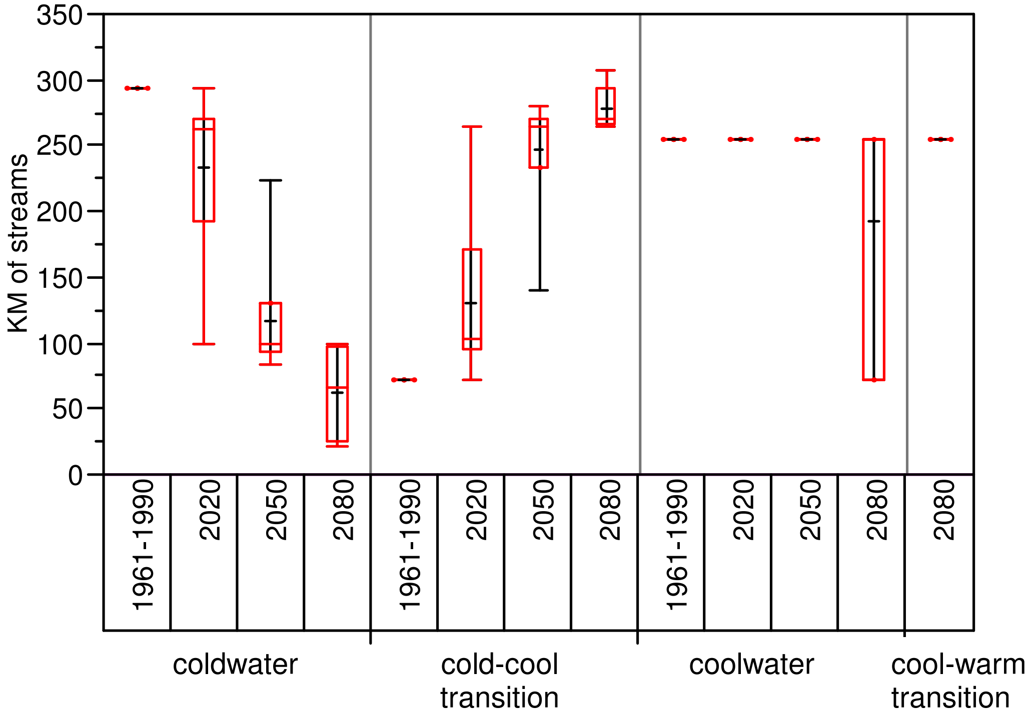

Figure 22. Linear extent (km) of thermal habitats across **Churn Creek** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

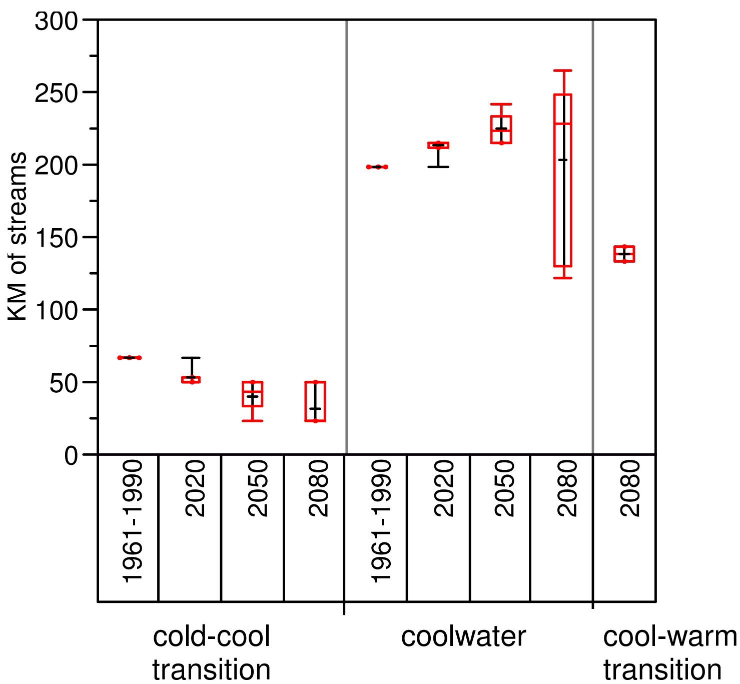

Figure 23. Linear extent (km) of thermal habitats across **Naver Creek** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

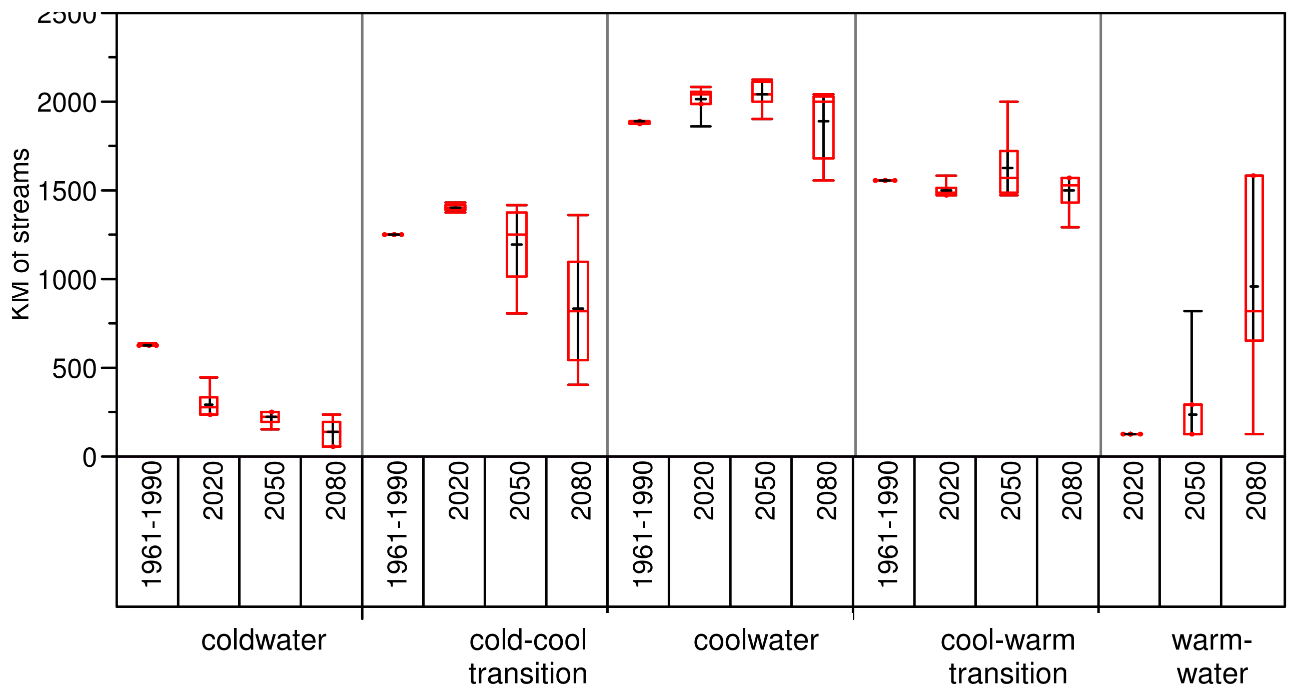

Figure 24. Linear extent (km) of thermal habitats across **Quesnel River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

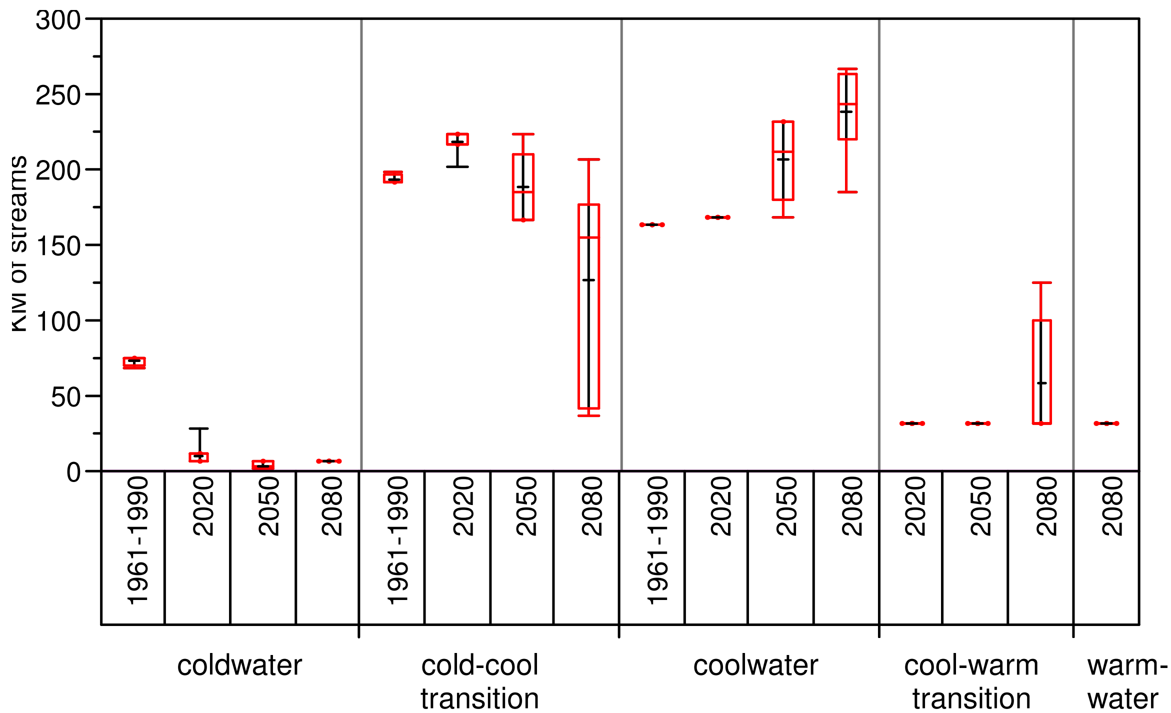

Figure 25. Linear extent (km) of thermal habitats across **Seton River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

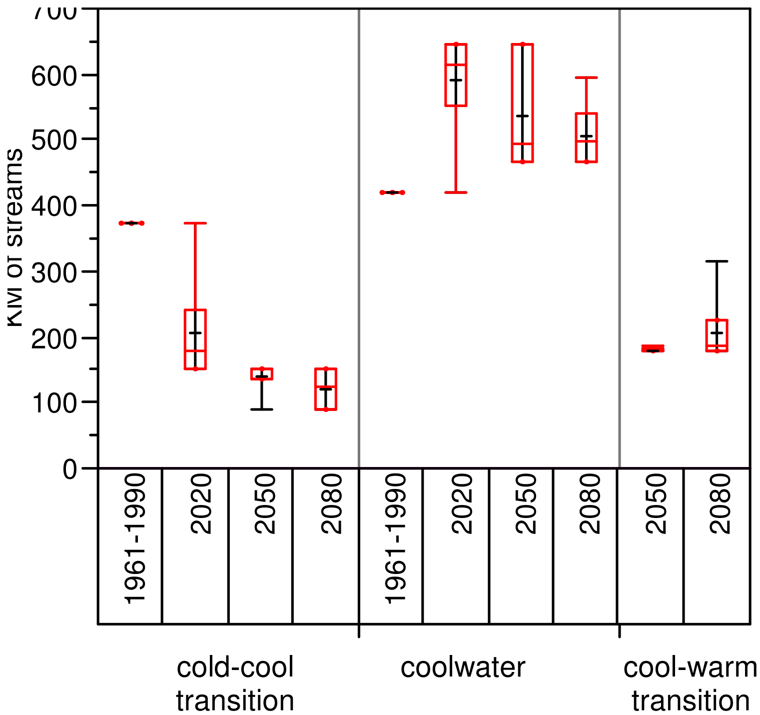

Figure 26. Linear extent (km) of thermal habitats across **Swift River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

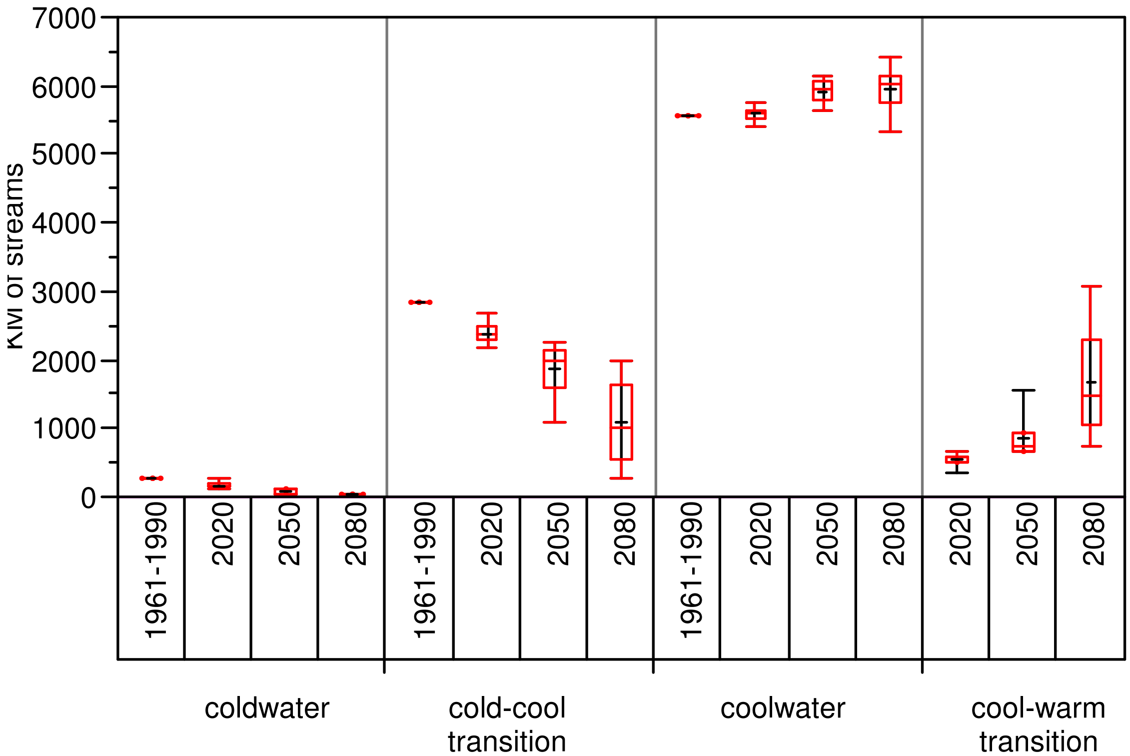

Figure 27. Linear extent (km) of thermal habitats across **West Road River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

4.3 Suitability for Chinook salmon

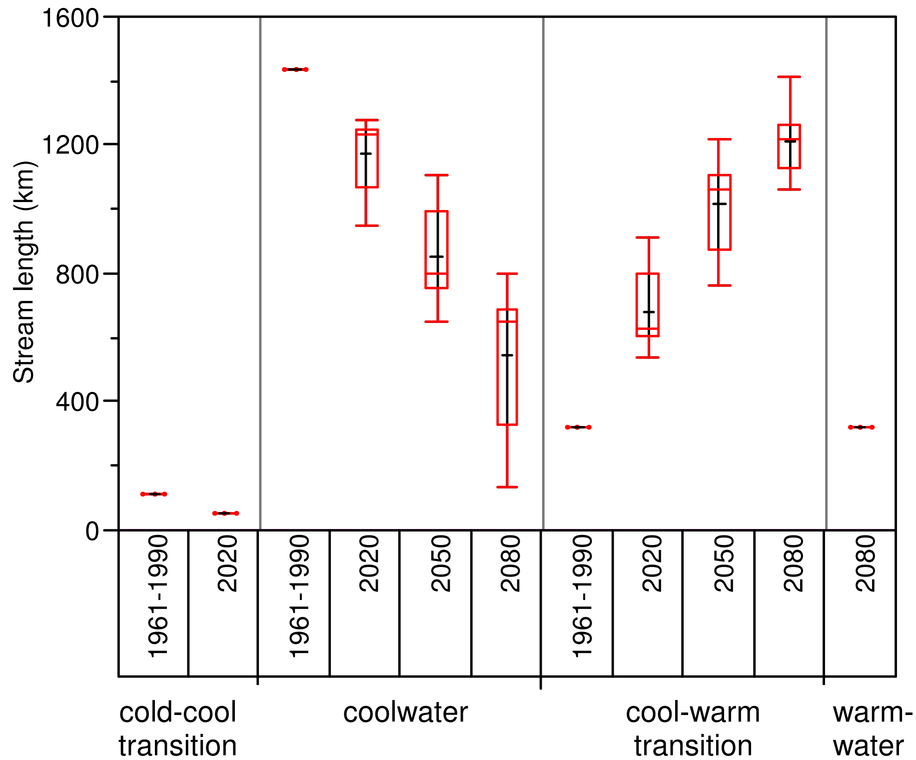

Figure 28. Linear extent (km) of thermal habitat classes across the **Middle Fraser spring timing Conservation Unit** for Chinook as compared across a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

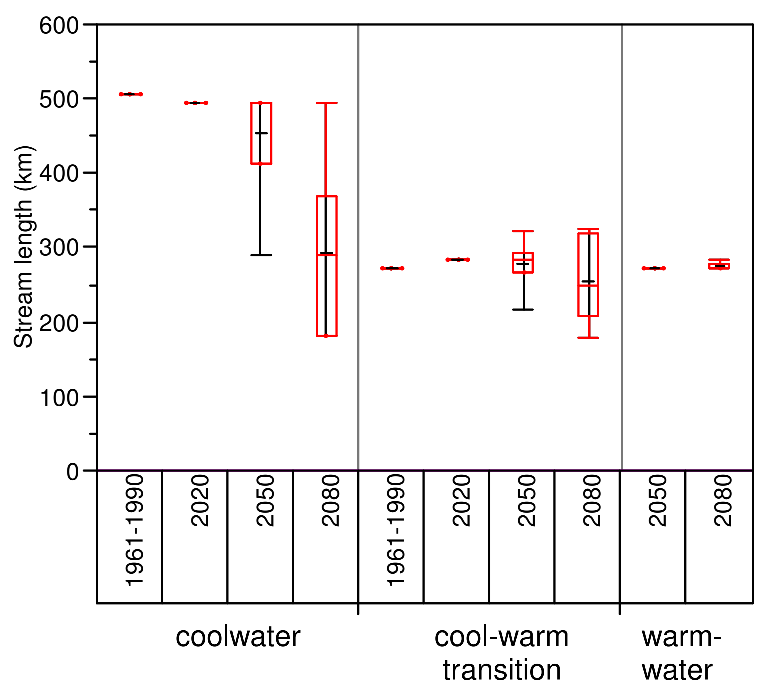

Figure 29. Linear extent (km) of thermal habitat classes across the **Middle Fraser summer timing Conservation Unit** for Chinook as compared across a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

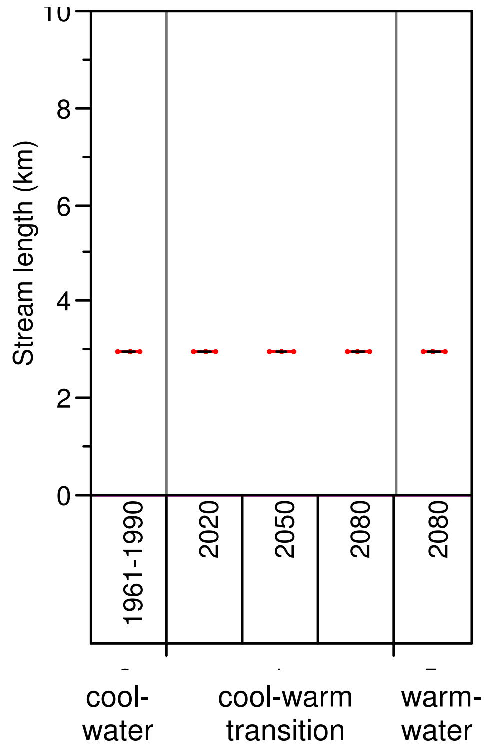

Figure 30. Linear extent (km) of thermal habitat classes across the **Middle Fraser Portage Conservation Unit** for Chinook as compared across a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

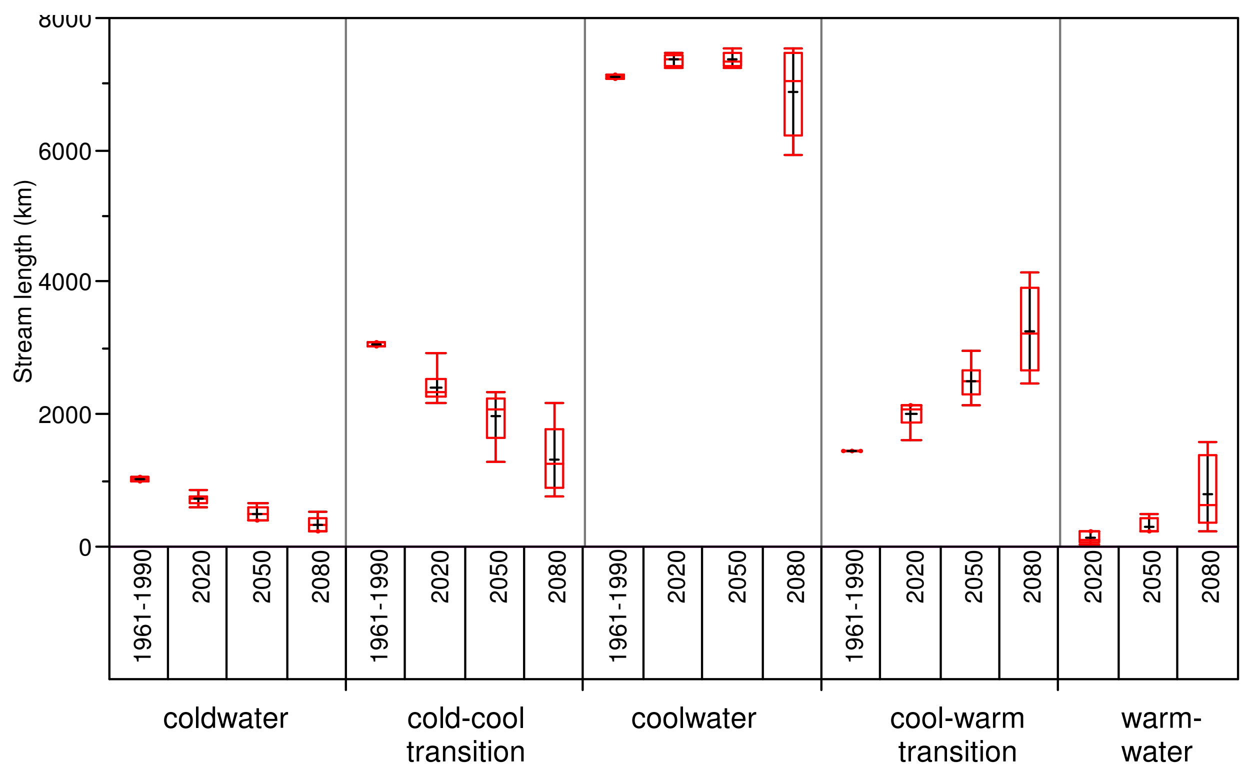

Figure 31. Linear extent (km) of thermal habitat classes across the Cariboo-Chilcotin for areas not captured within above Conservation Unit boundaries for Chinook as compared across a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

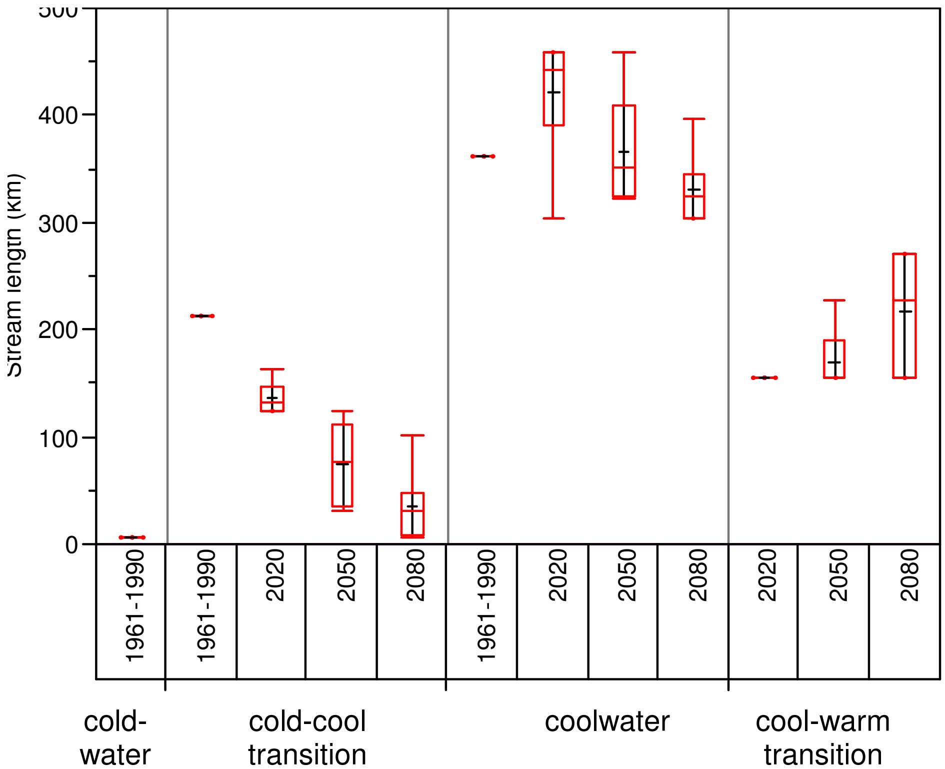

Figure 32. Linear extent (km) of thermal habitats across **Baker Creek stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

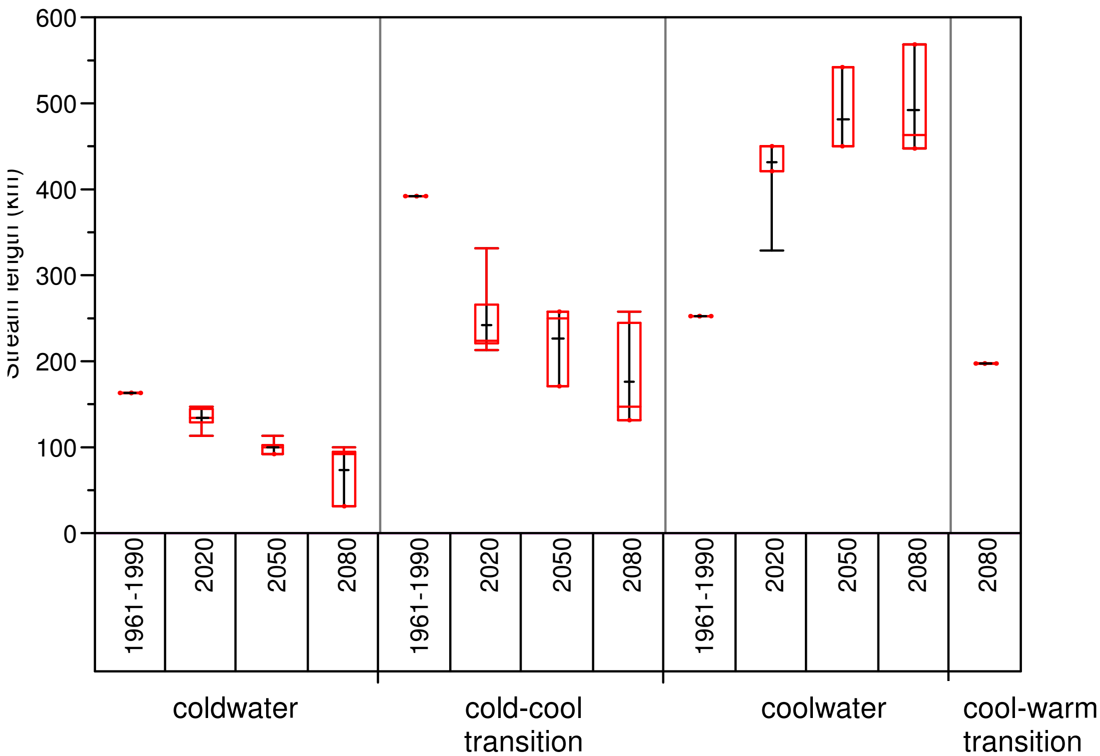

Figure 33. Linear extent (km) of thermal habitats across **Big Creek stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

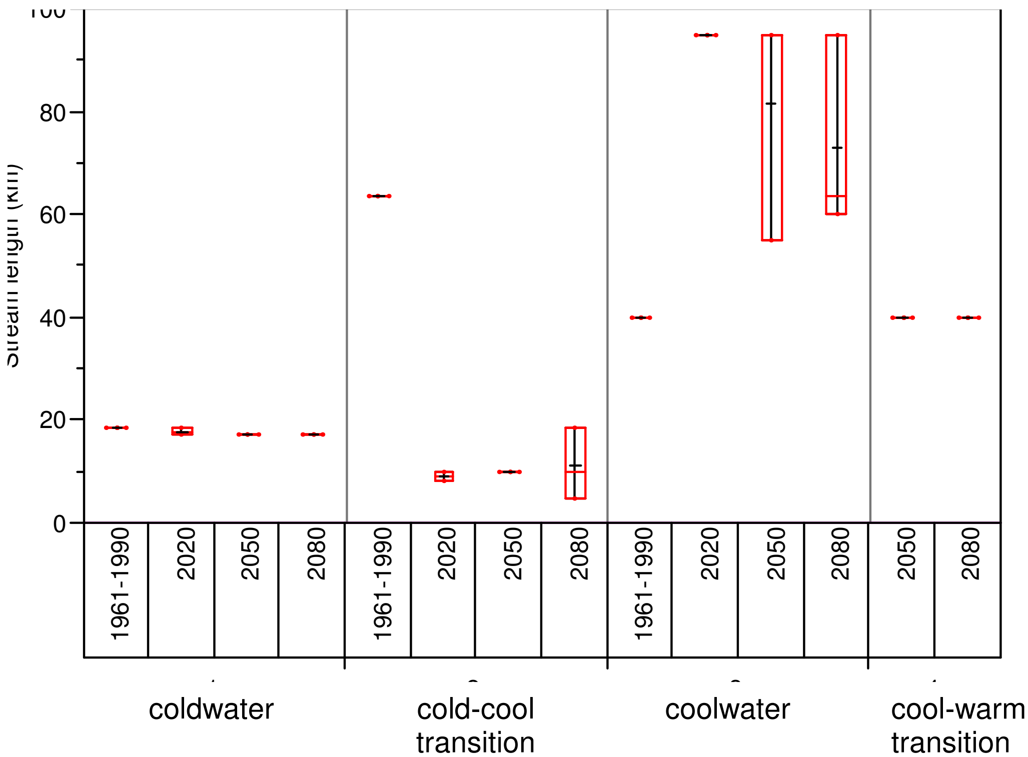

Figure 34. Linear extent (km) of thermal habitats across **Bridge River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

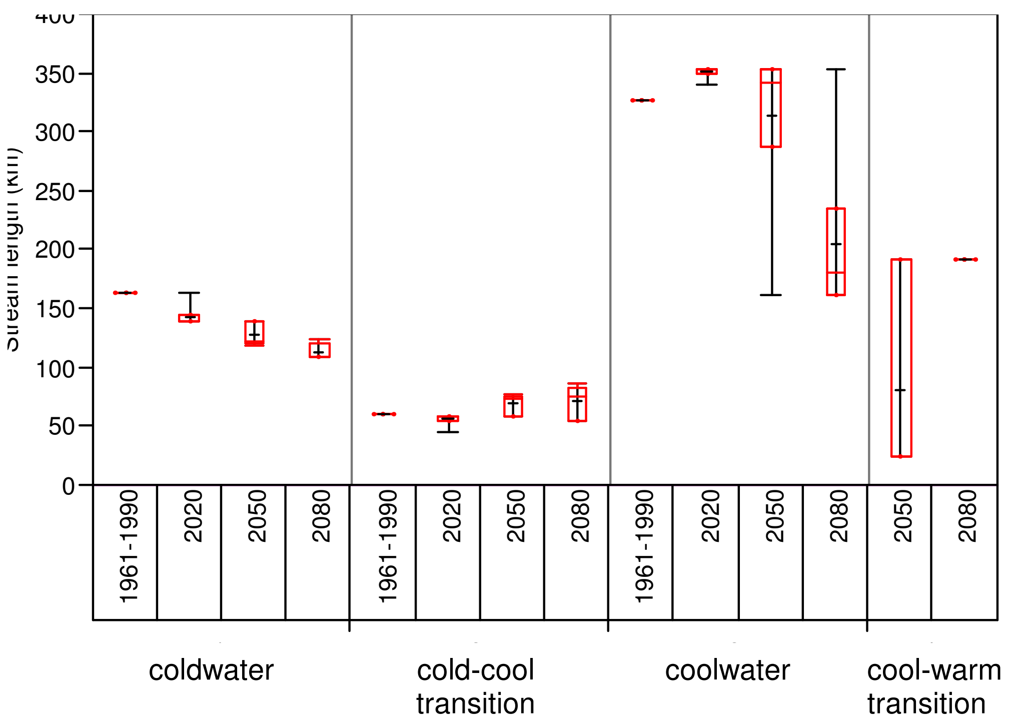

Figure 35. Linear extent (km) of thermal habitats across **Chilko River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

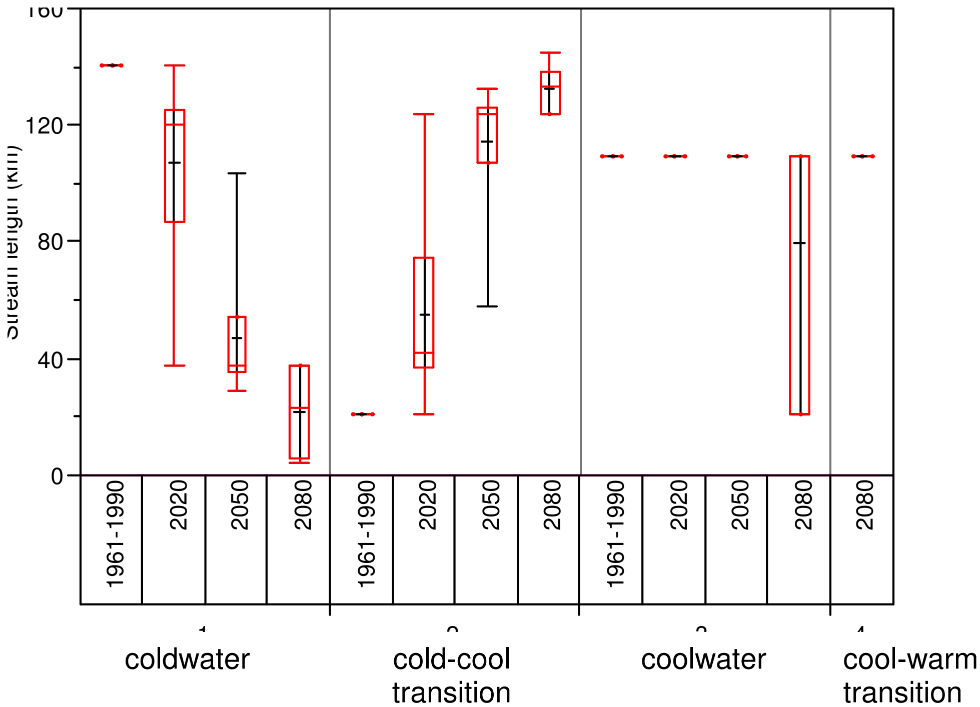

Figure 36. Linear extent (km) of thermal habitats across **Churn Creek stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

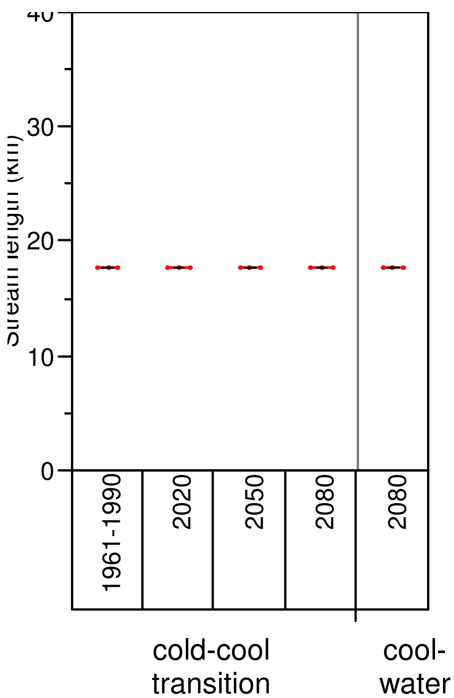

Figure 37. Linear extent (km) of thermal habitats across **Cottonwood Creek stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

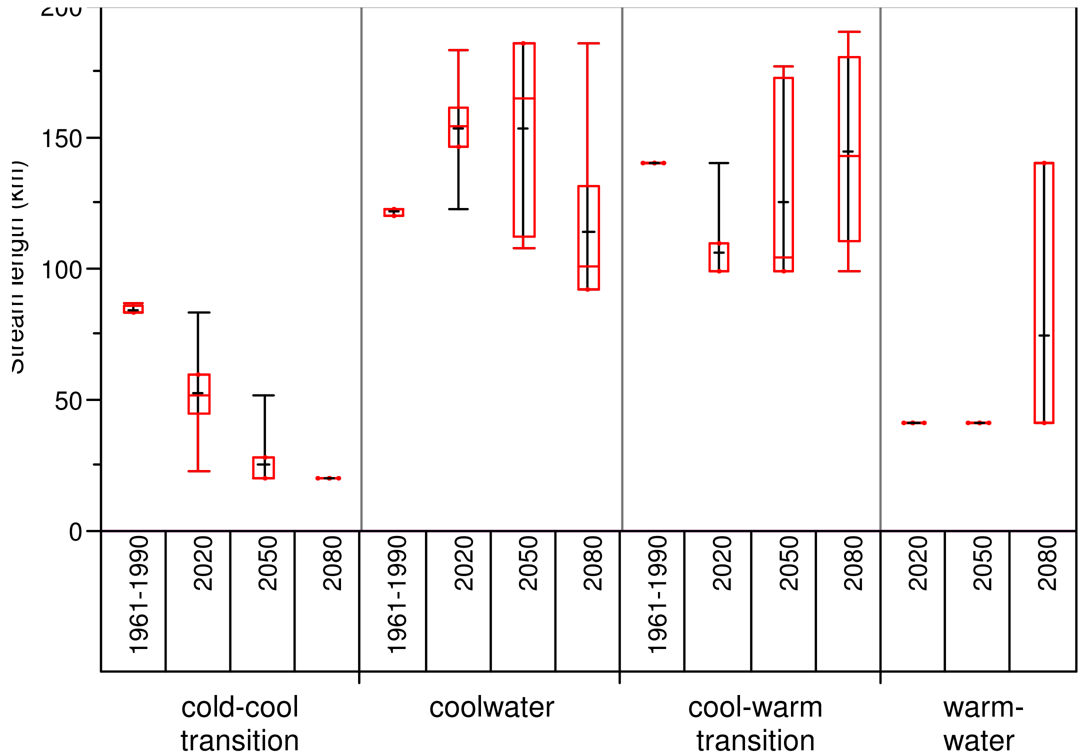

Figure 38. Linear extent (km) of thermal habitats across **Horsefly River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

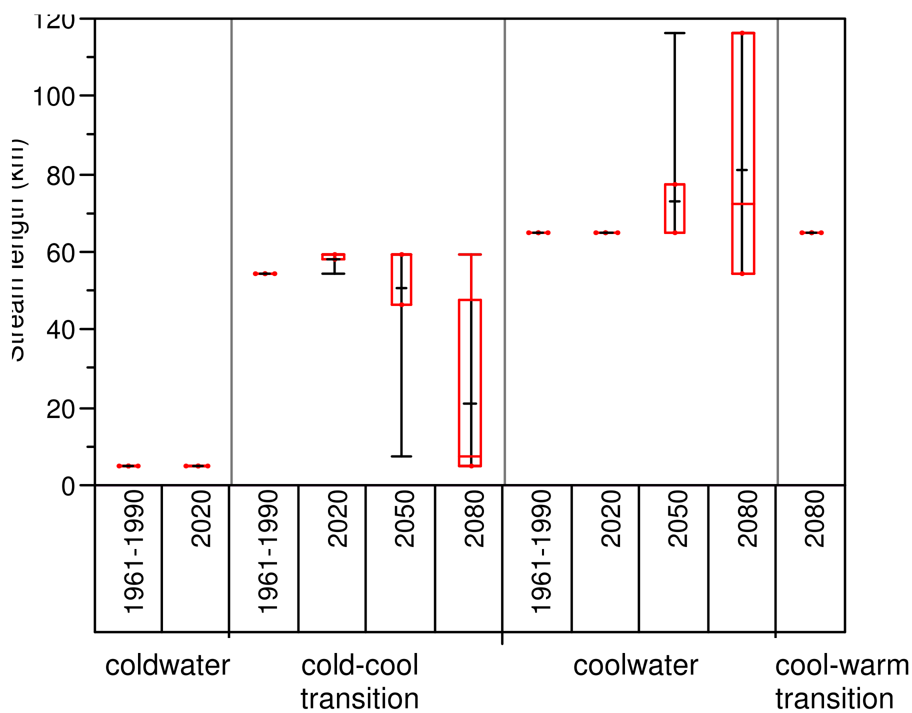

Figure 39. Linear extent (km) of thermal habitats across **Lower Cariboo River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

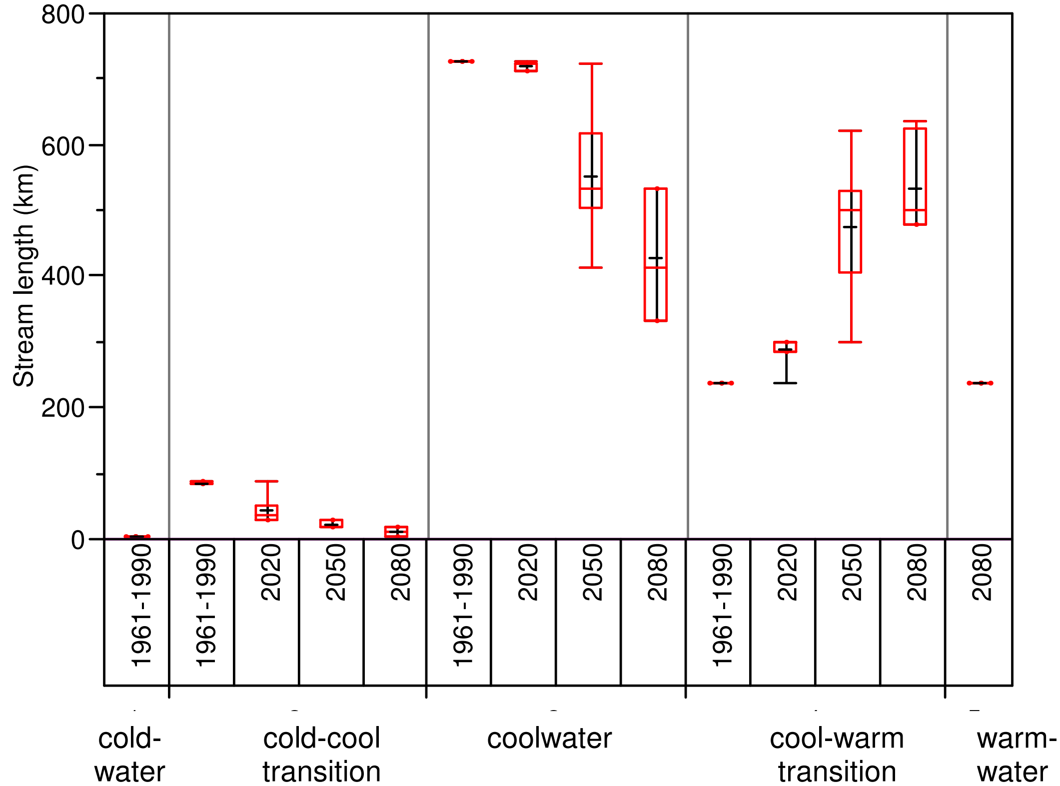

Figure 40. Linear extent (km) of thermal habitats across **Lower Chilcotin River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

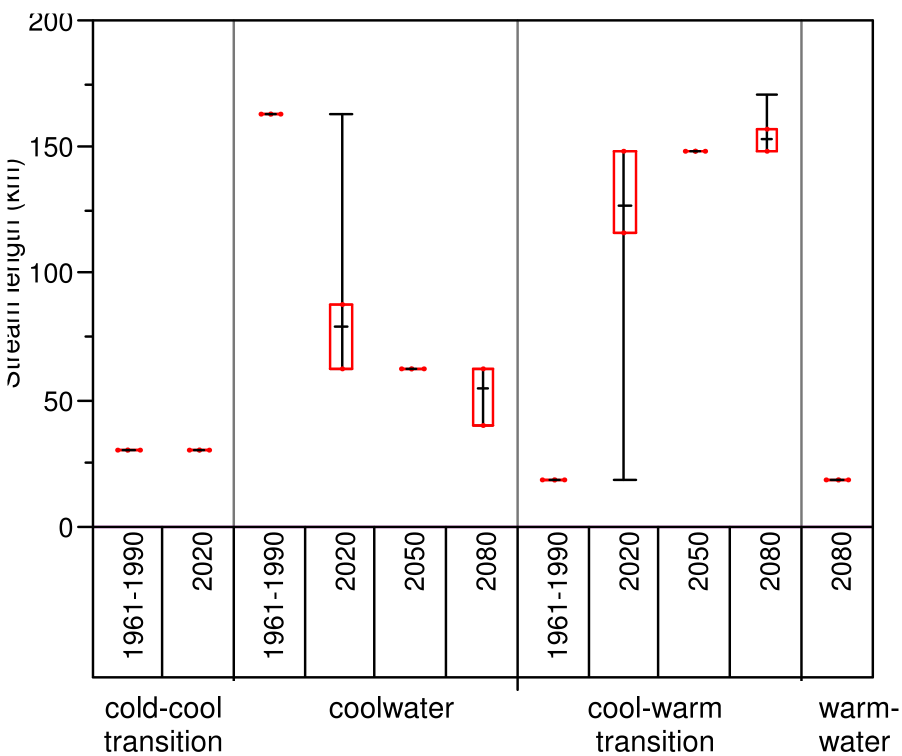

Figure 41. Linear extent (km) of thermal habitats across **Mackin Creek stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

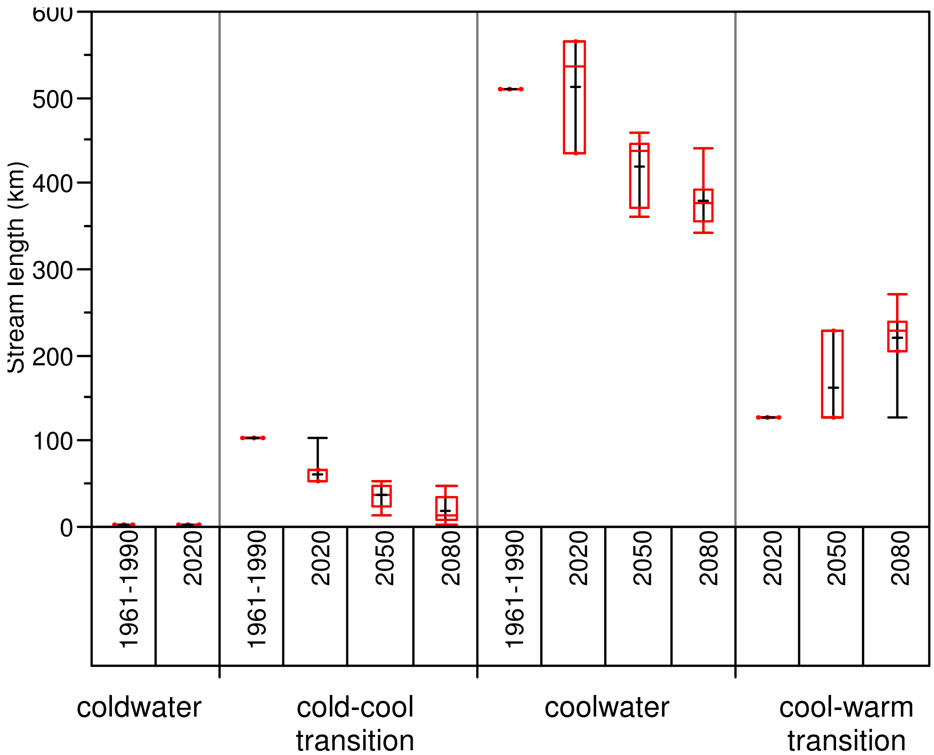

Figure 42. Linear extent (km) of thermal habitats across **Narcosli Creek stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

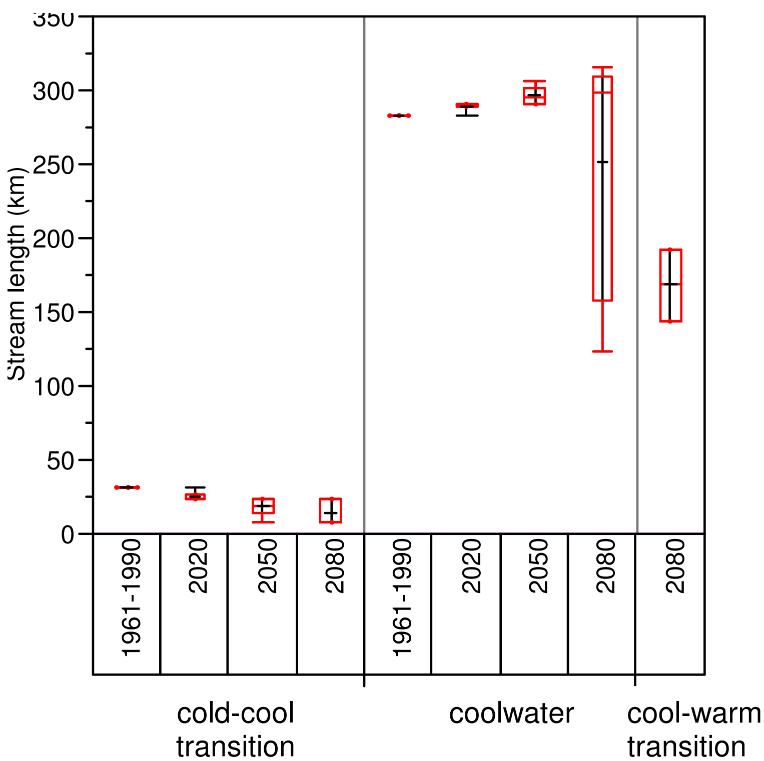

Figure 43. Linear extent (km) of thermal habitats across **Naver Creek stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

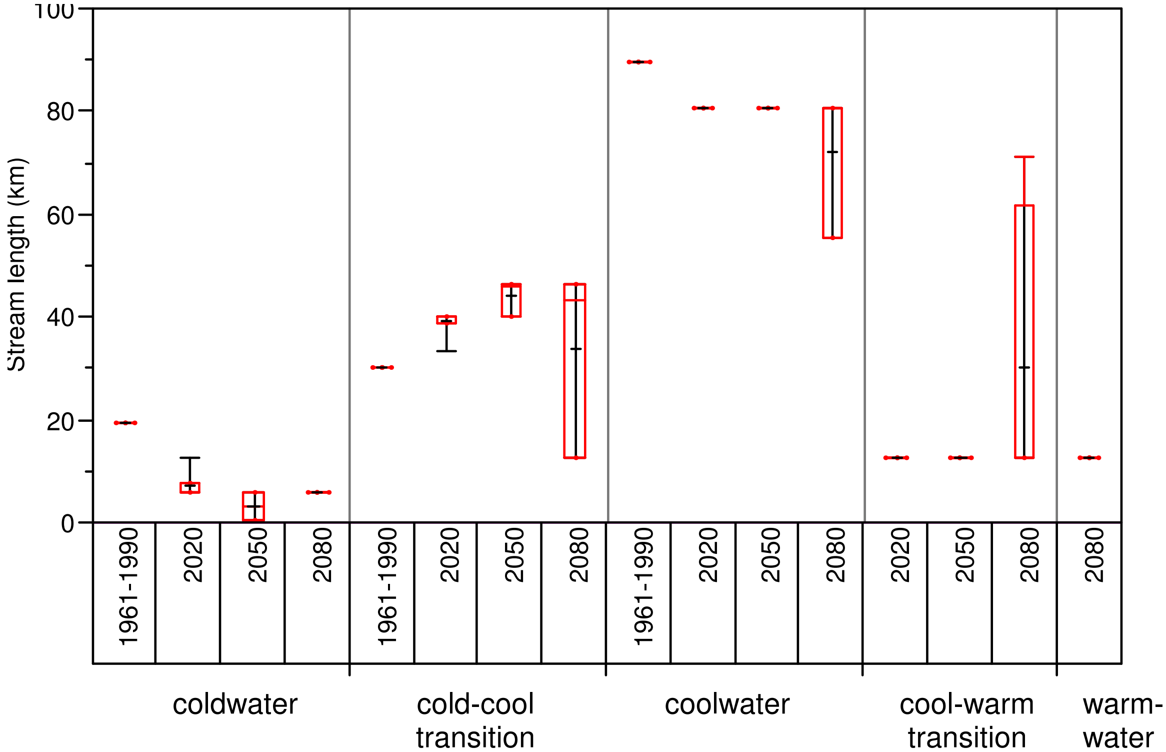

Figure 44. Linear extent (km) of thermal habitats across **Portage Creek stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

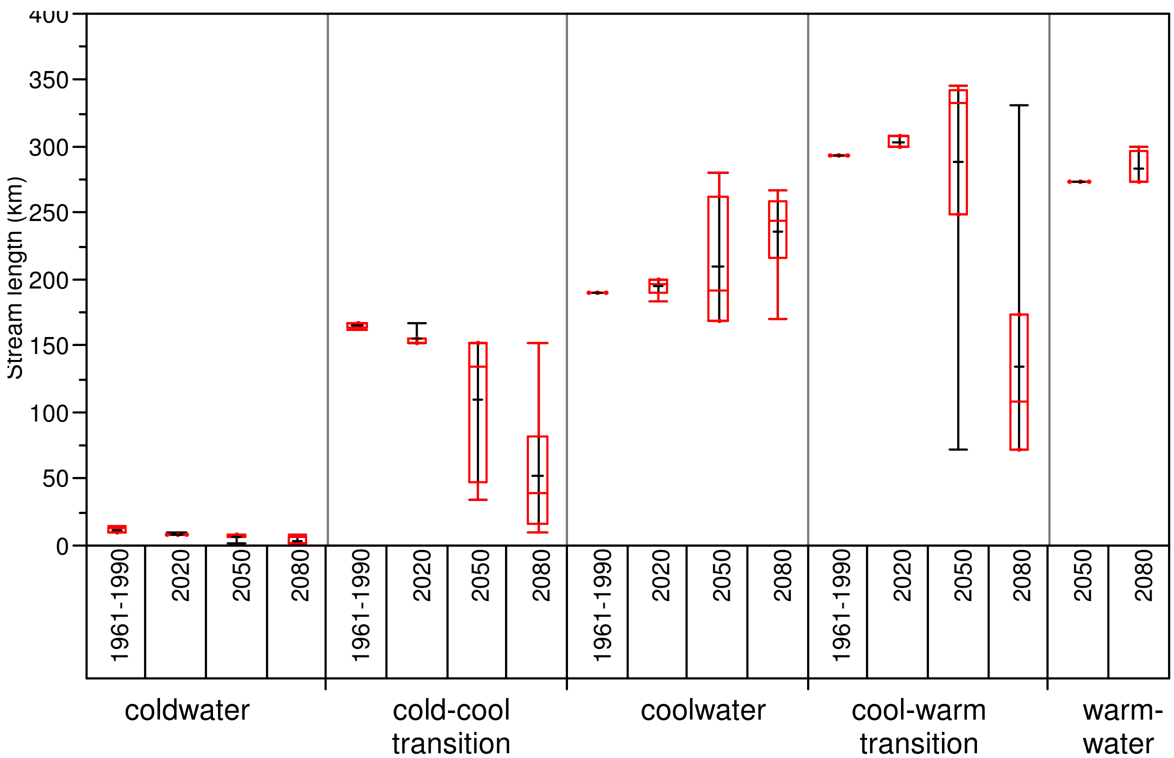

Figure 45. Linear extent (km) of thermal habitats across **Quesnel River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

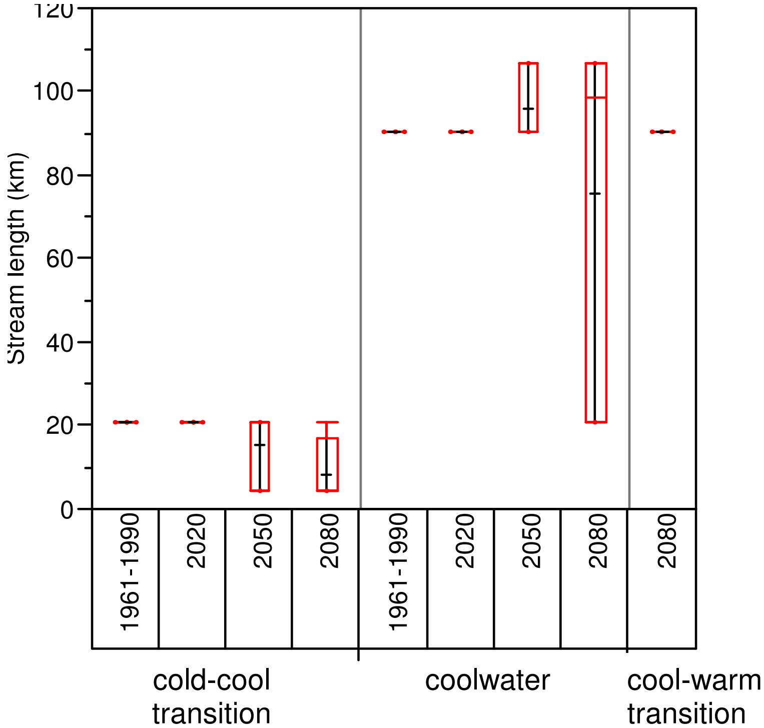

Figure 46. Linear extent (km) of thermal habitats across **Stein River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

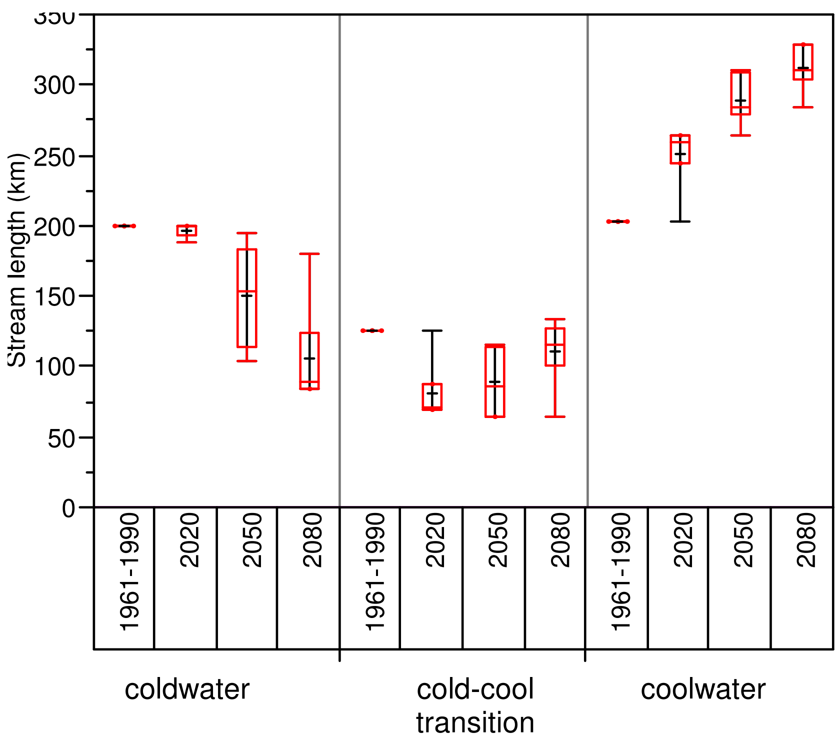

Figure 47. Linear extent (km) of thermal habitats across **Taseko River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

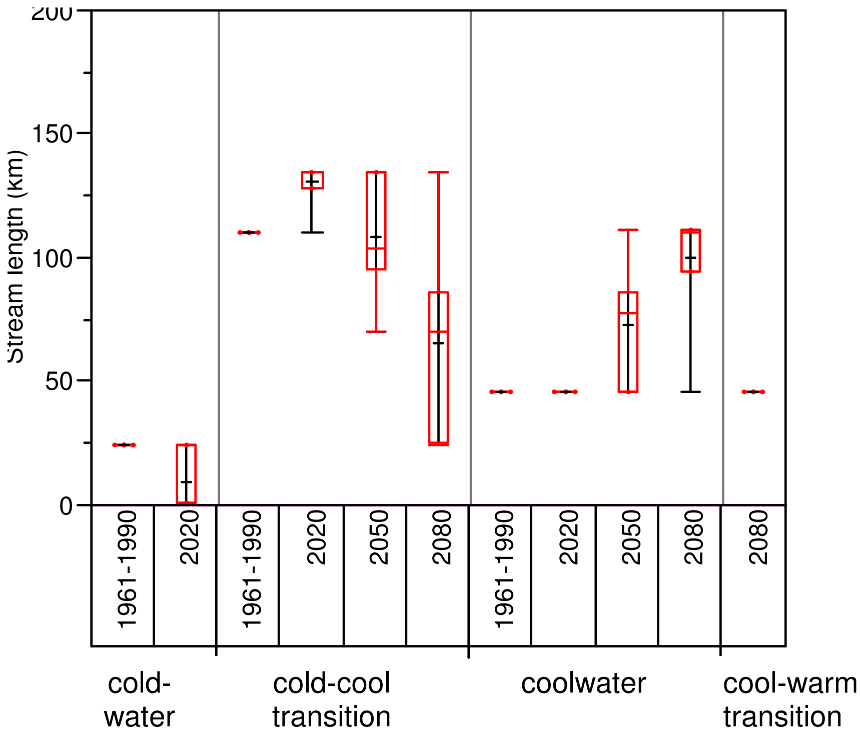

Figure 48. Linear extent (km) of thermal habitats across **Upper Cariboo River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

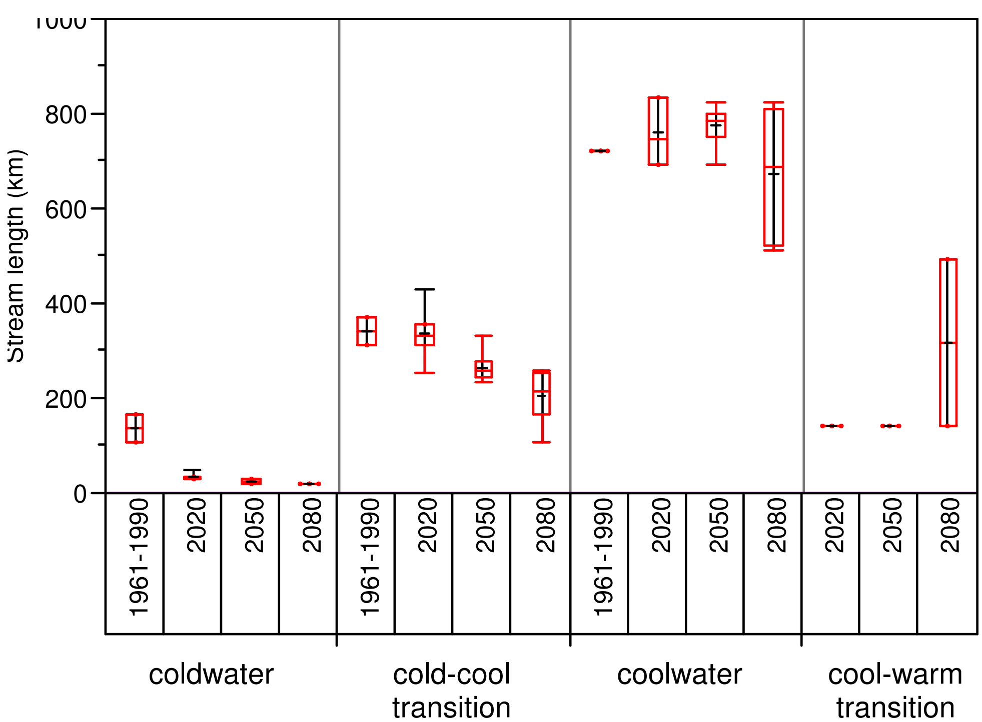

Figure 49. Linear extent (km) of thermal habitats across **Upper Chilcotin River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

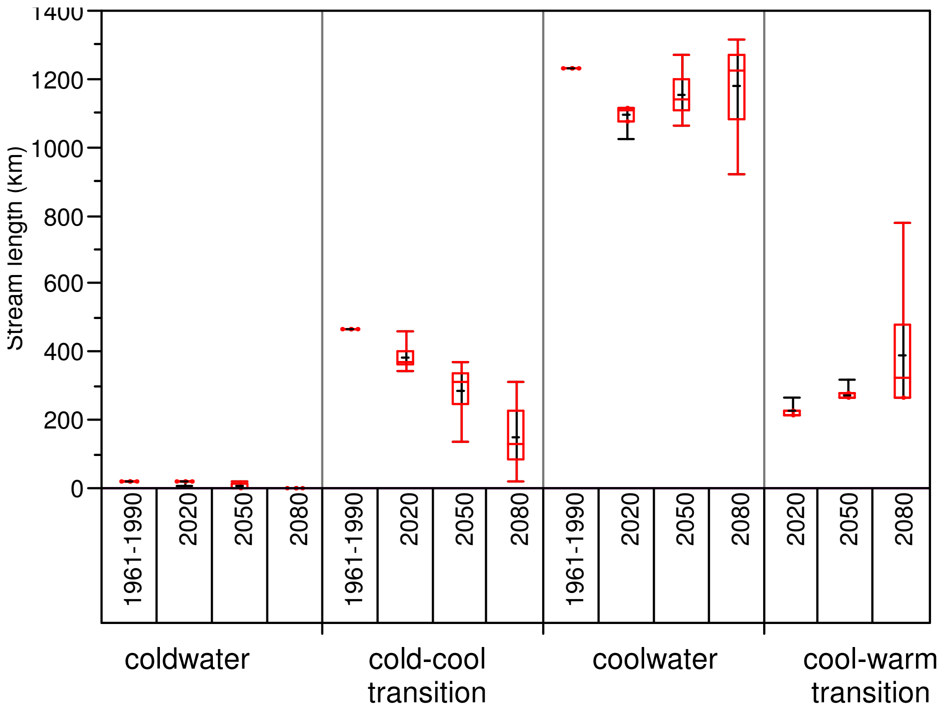

Figure 50. Linear extent (km) of thermal habitats across **West Road River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

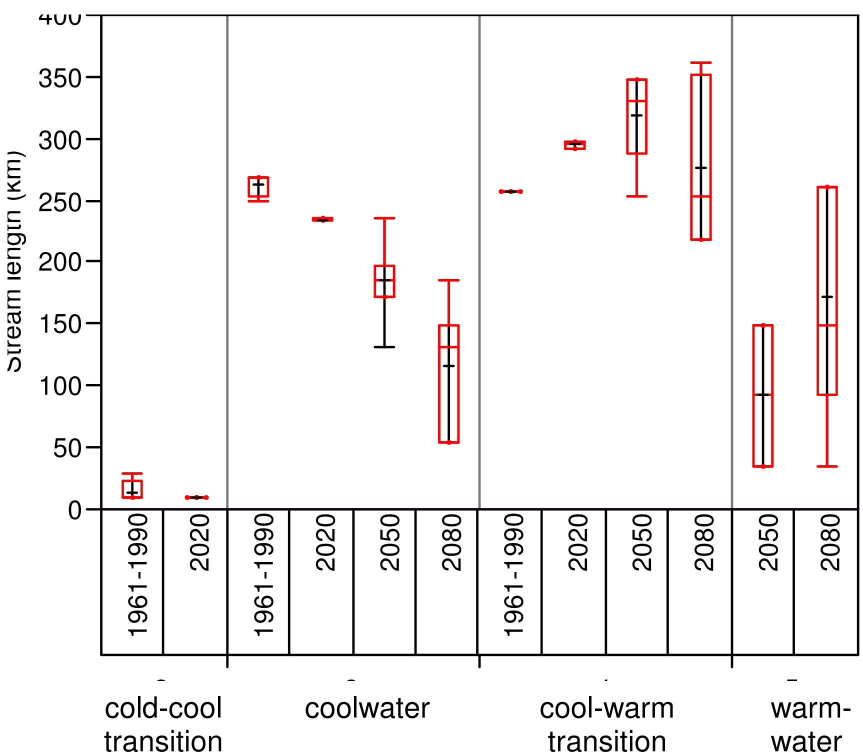

Figure 51. Linear extent (km) of thermal habitats across **Williams Lake River stock unit** in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

4.4 Suitability for coho salmon

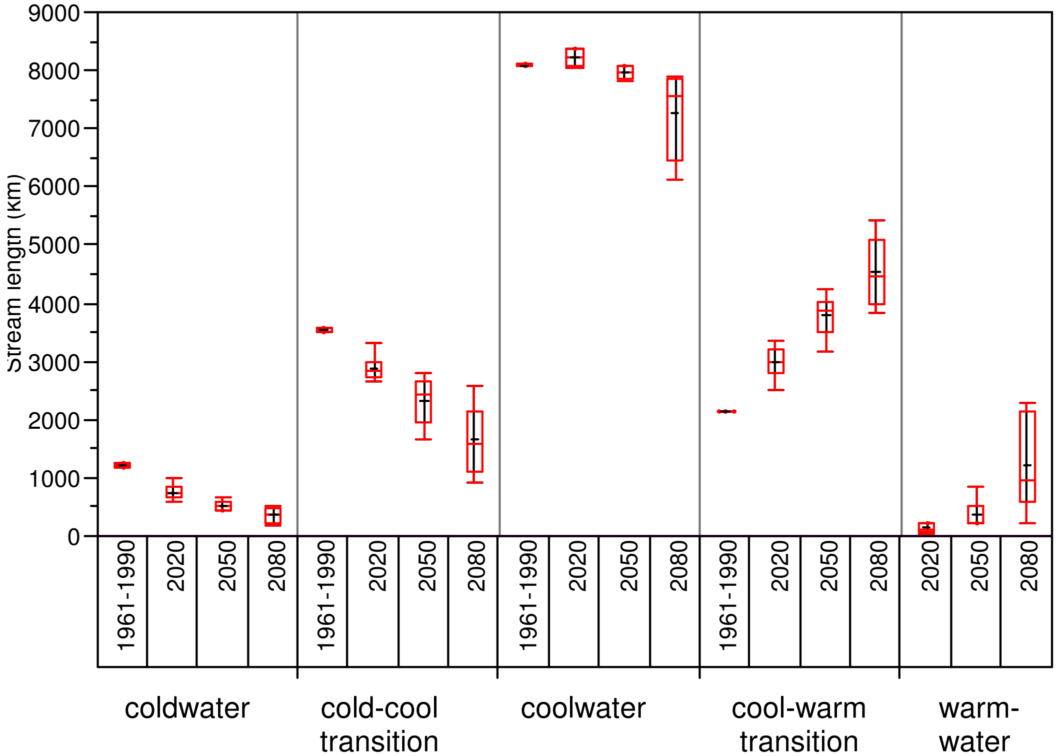

Figure 52. Linear extent (km) of thermal habitat classes across the **Middle Fraser Conservation Unit** for coho as compared across a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

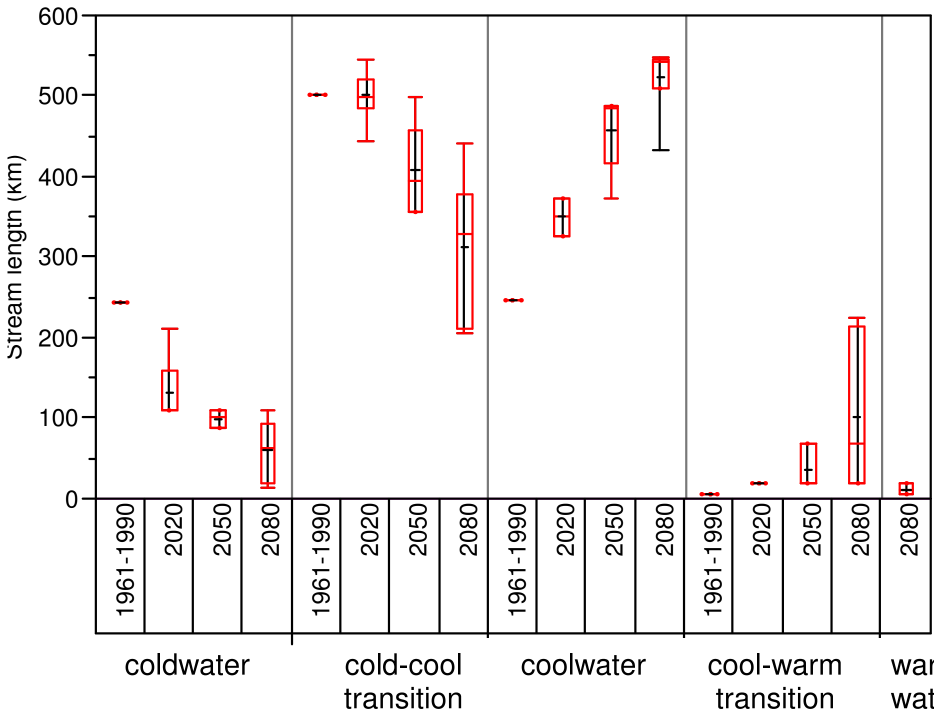

Figure 53. Linear extent (km) of thermal habitat classes across the **Middle Upper Fraser sub-population** as compared across a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

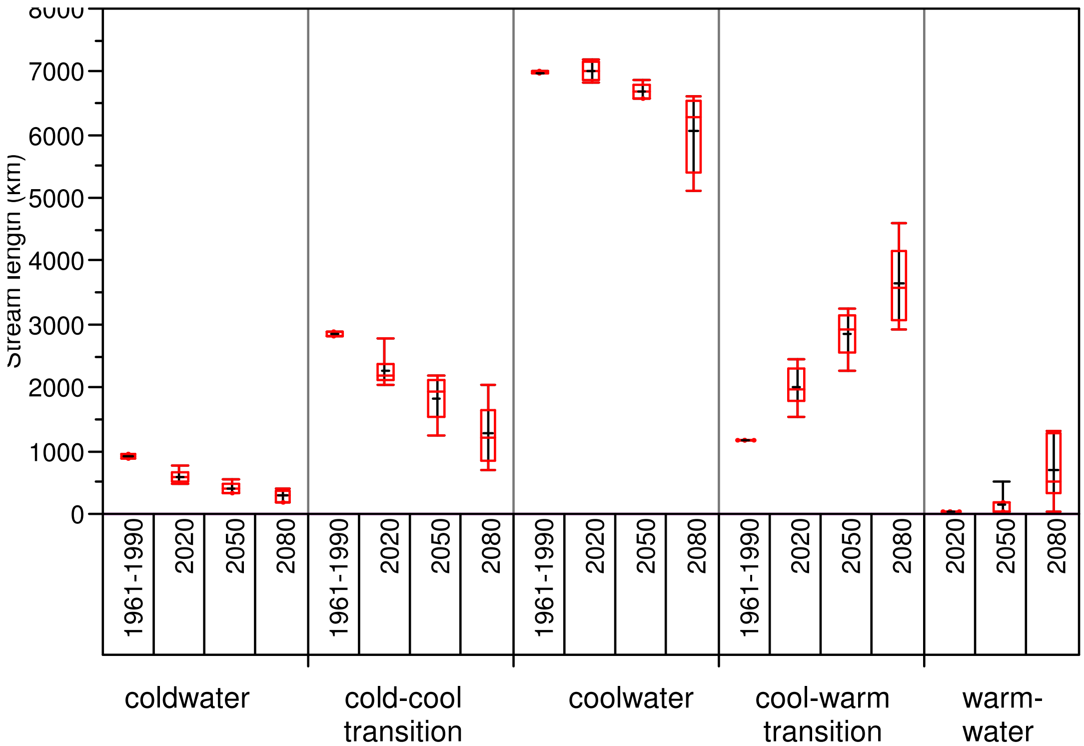

Figure 54. Linear extent (km) of thermal habitat classes across the **Upper Upper Fraser sub-population** as compared across a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

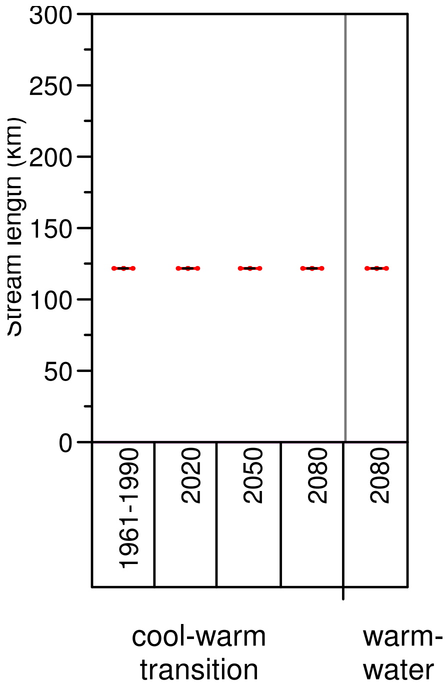

Figure 55. Linear extent (km) of thermal habitats across **Alkali Creek** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

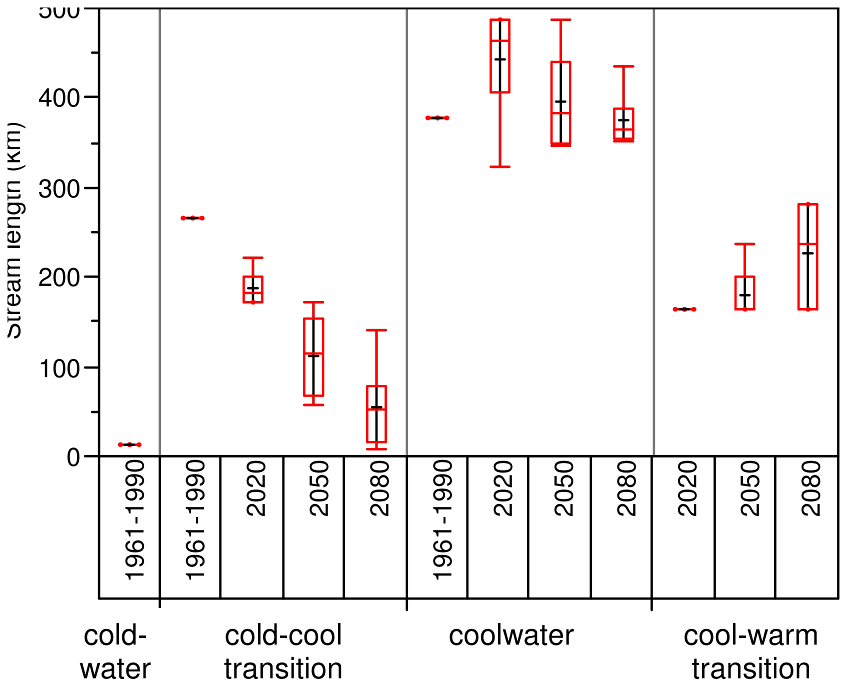

Figure 56. Linear extent (km) of thermal habitats across **Baker Creek** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

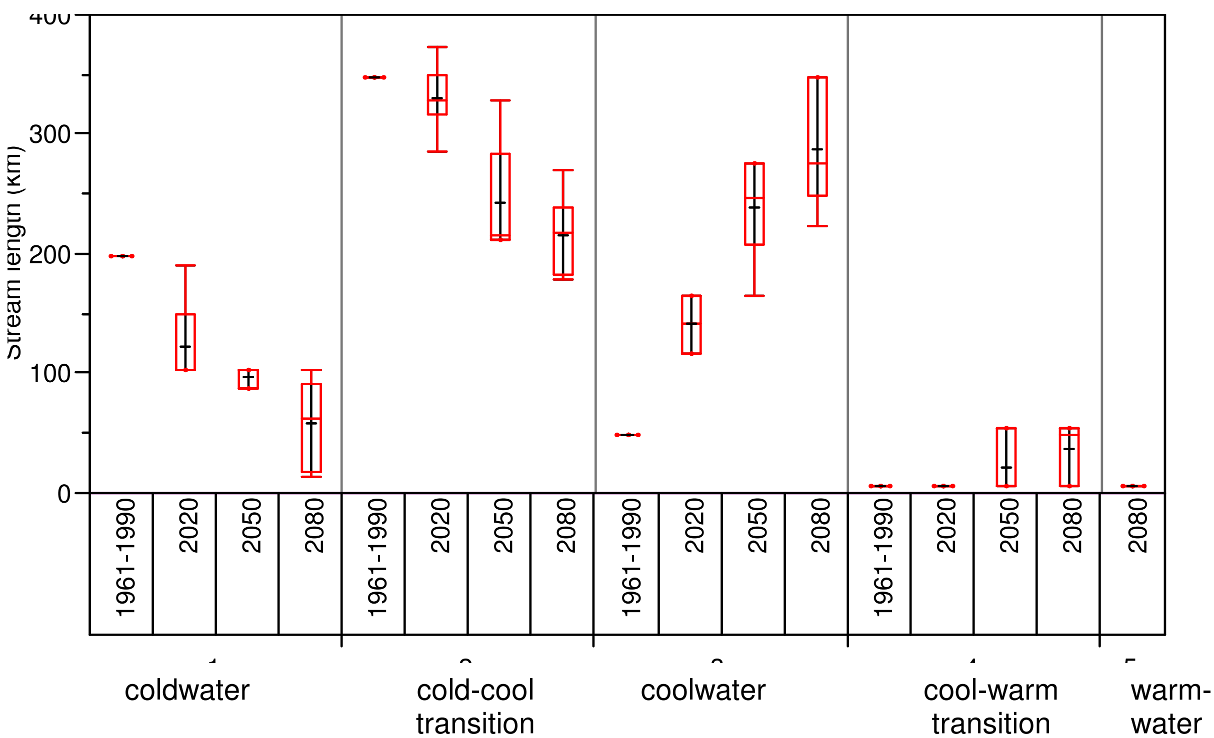

Figure 57. Linear extent (km) of thermal habitats across **Bridge River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

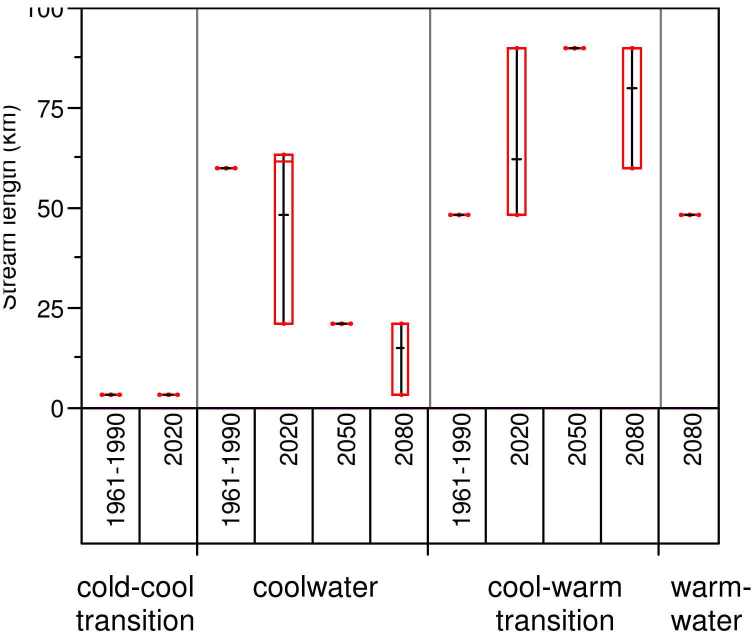

Figure 58. Linear extent (km) of thermal habitats across **Canoe River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

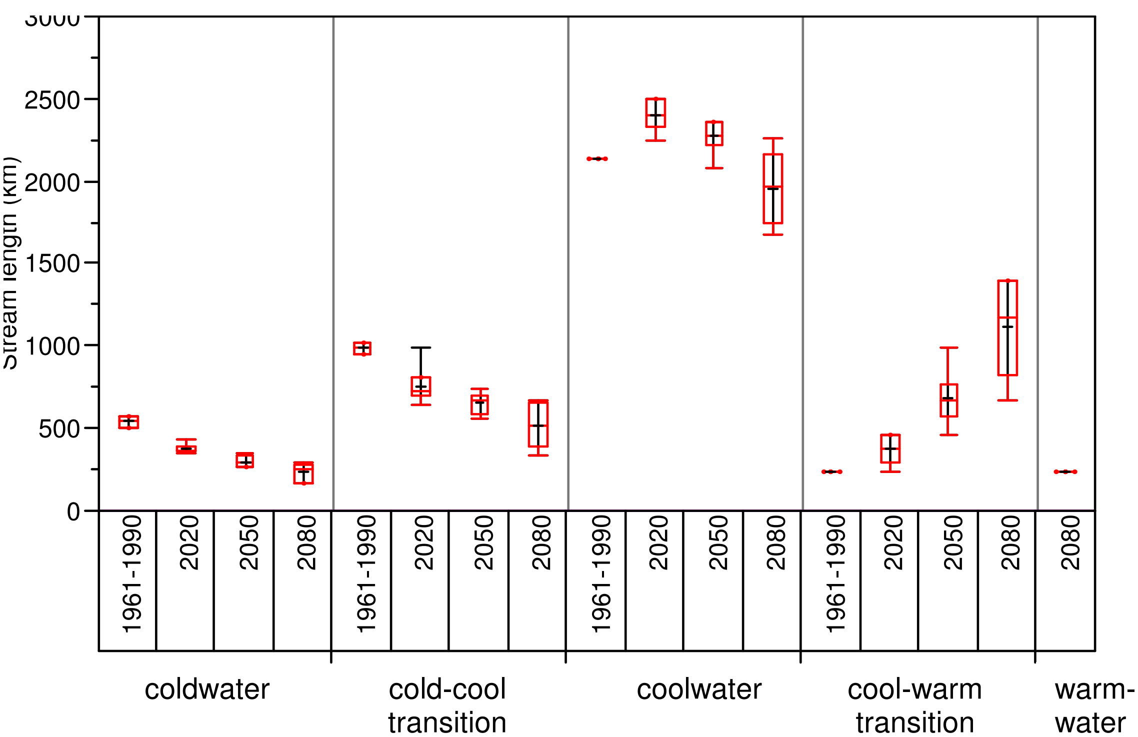

Figure 59. Linear extent (km) of thermal habitats across **Chilcotin River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

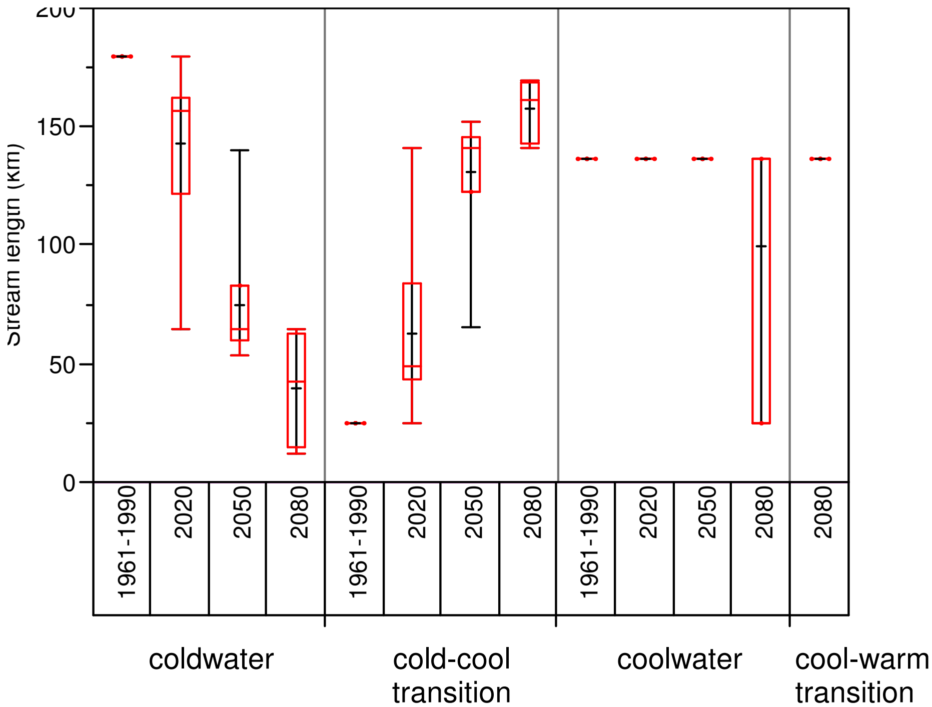

Figure 60. Linear extent (km) of thermal habitats across **Churn Creek** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

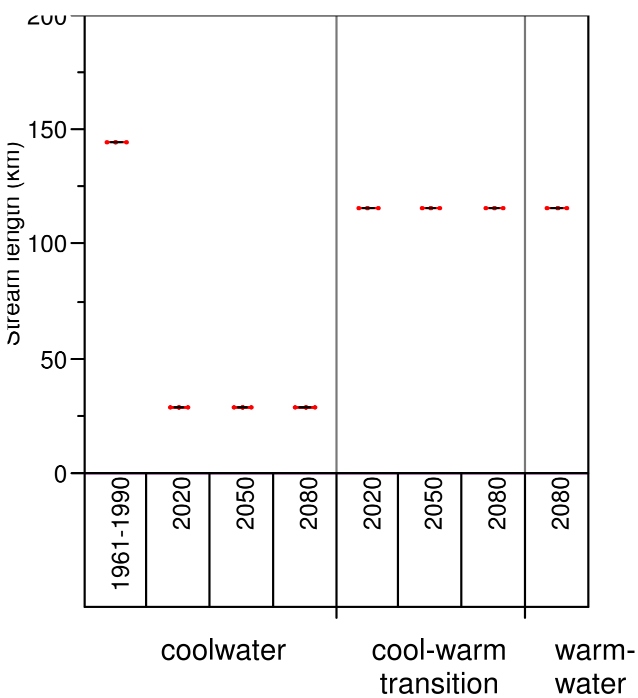

Figure 61. Linear extent (km) of thermal habitats across **Dog Creek** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

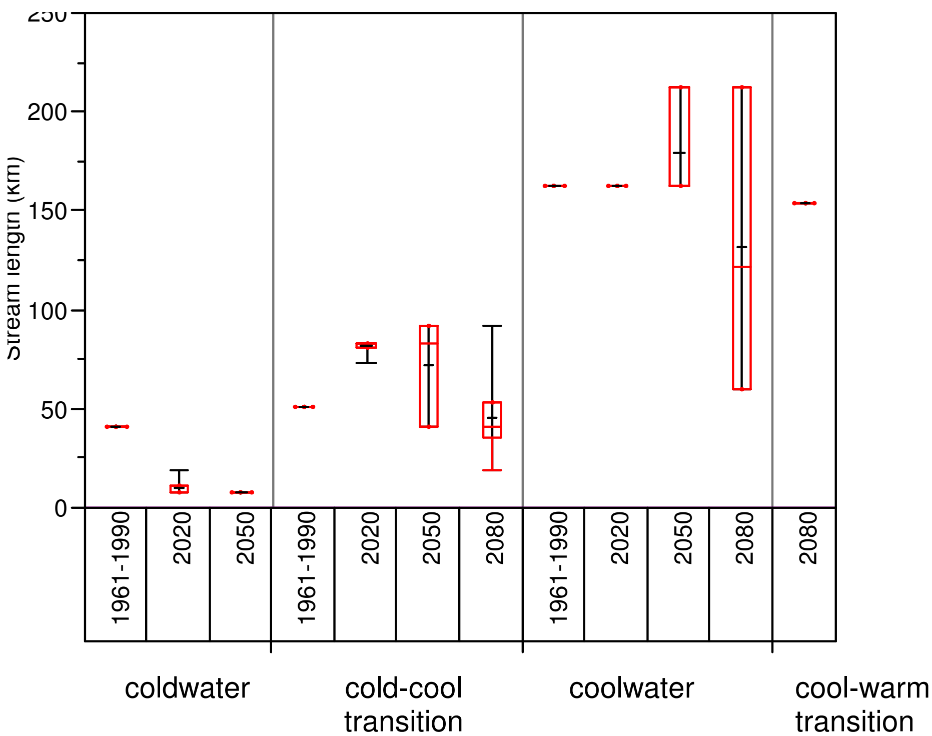

Figure 62. Linear extent (km) of thermal habitats across **Gaspard Creek** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

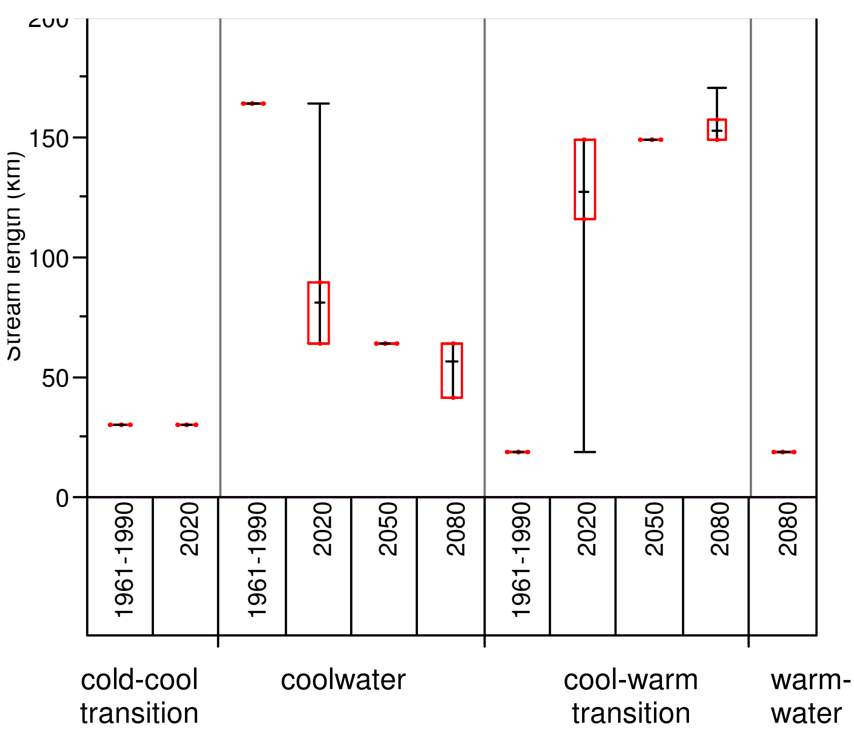

Figure 63. Linear extent (km) of thermal habitats across **Mackin Creek** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

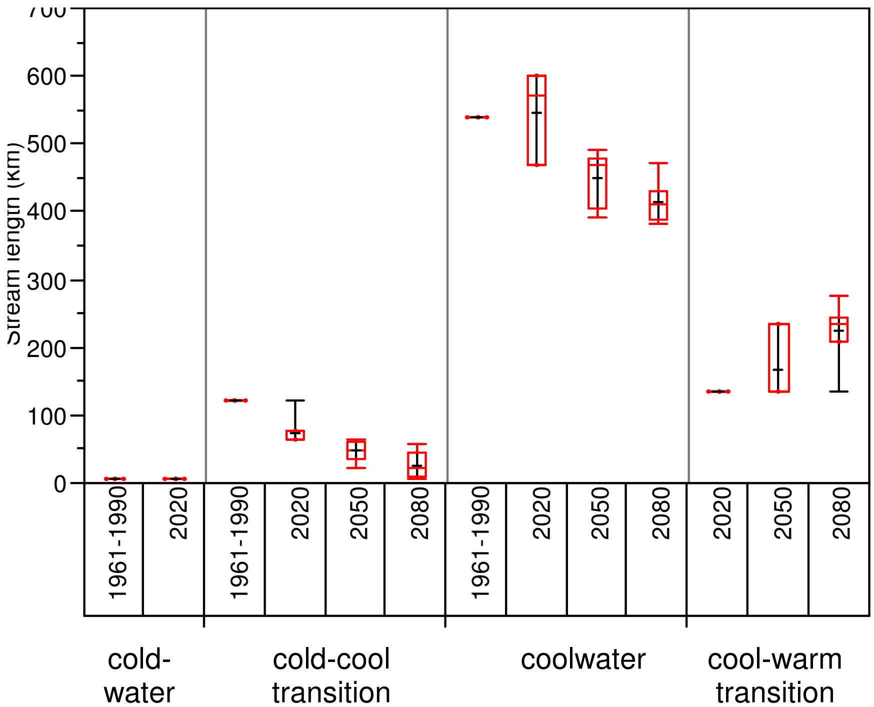

Figure 64. Linear extent (km) of thermal habitats across **Nacosli Creek** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

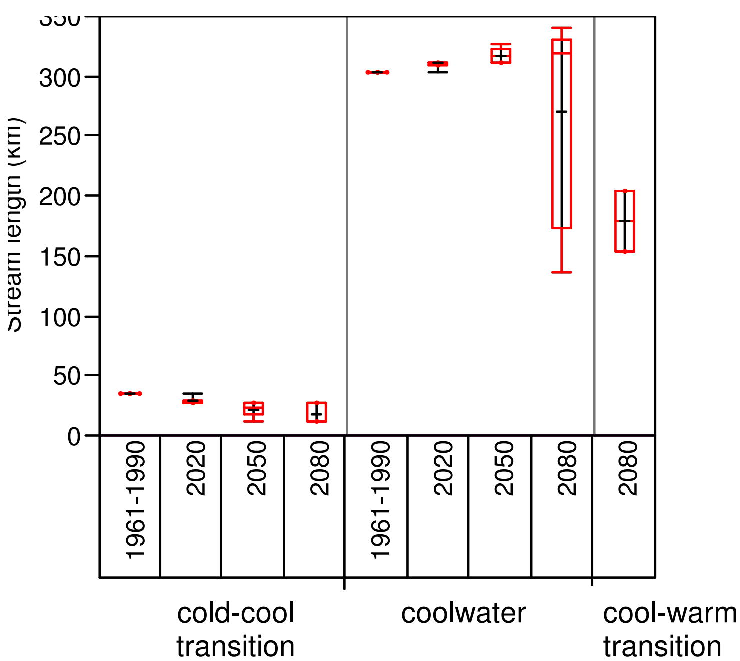

Figure 65. Linear extent (km) of thermal habitats across **Naver Creek** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

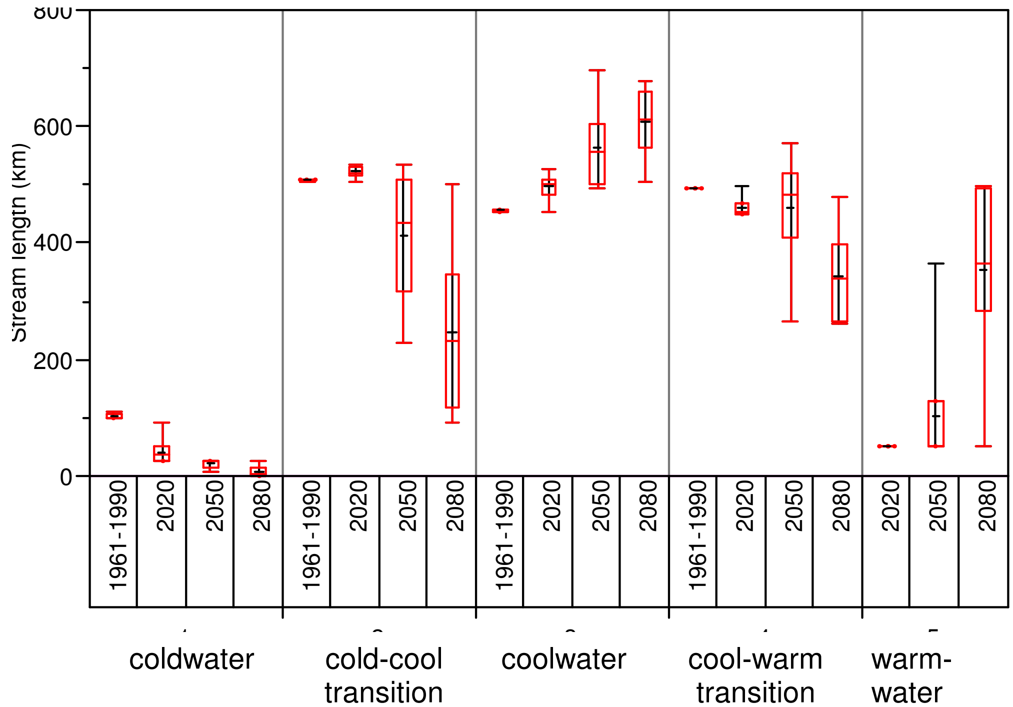

Figure 66. Linear extent (km) of thermal habitats across **Quesnel River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

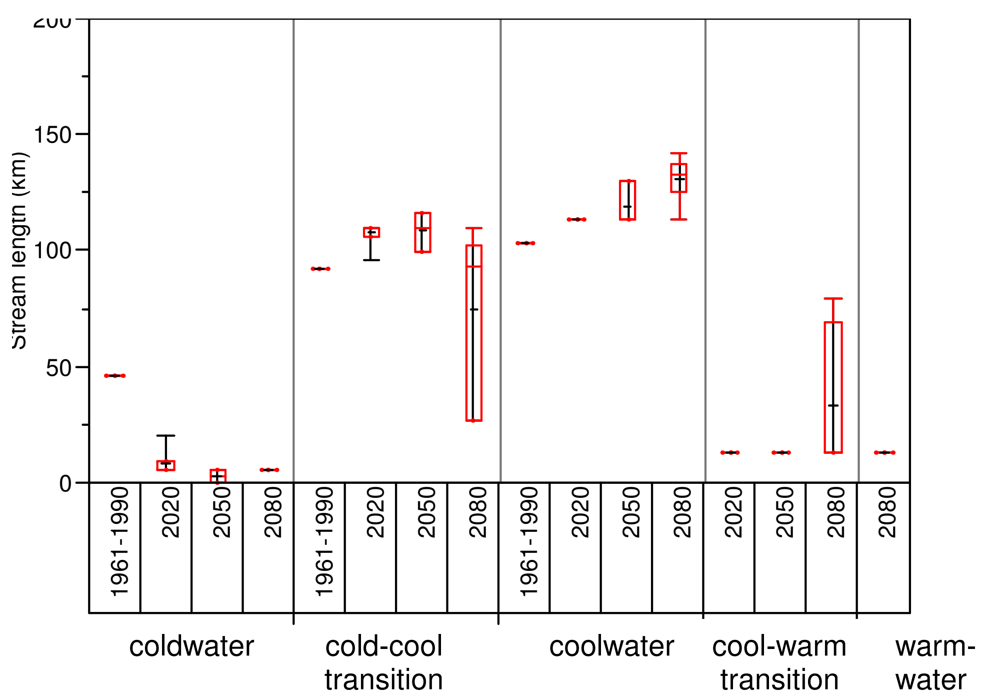

Figure 67. Linear extent (km) of thermal habitats across **Seton River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

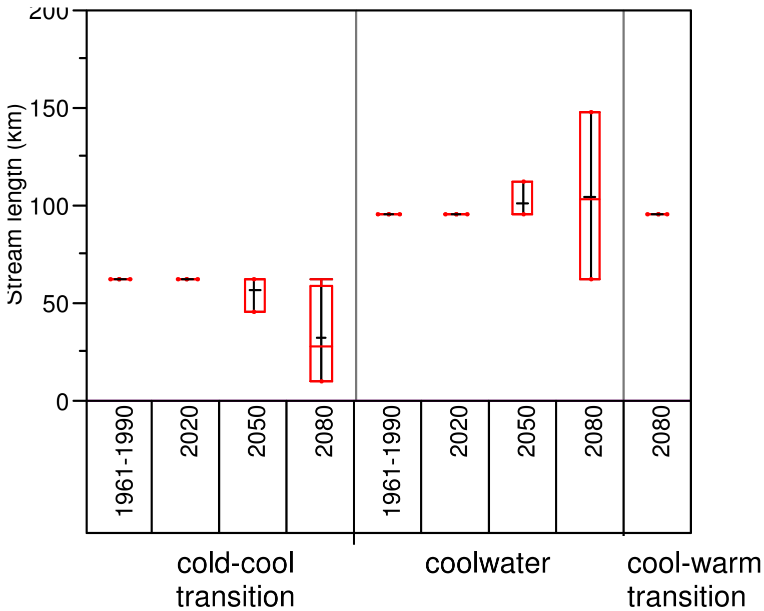

Figure 68. Linear extent (km) of thermal habitats across **Stein River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

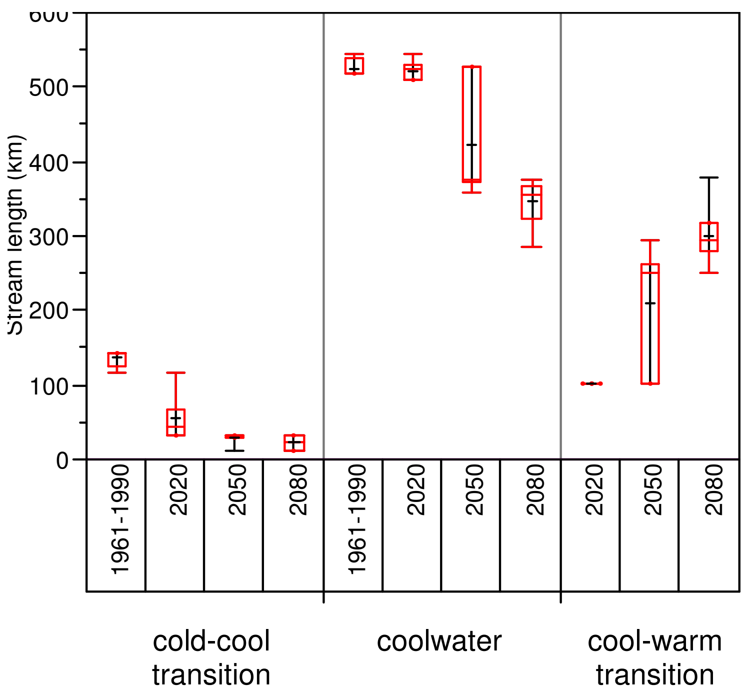

Figure 69. Linear extent (km) of thermal habitats across **Swift River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

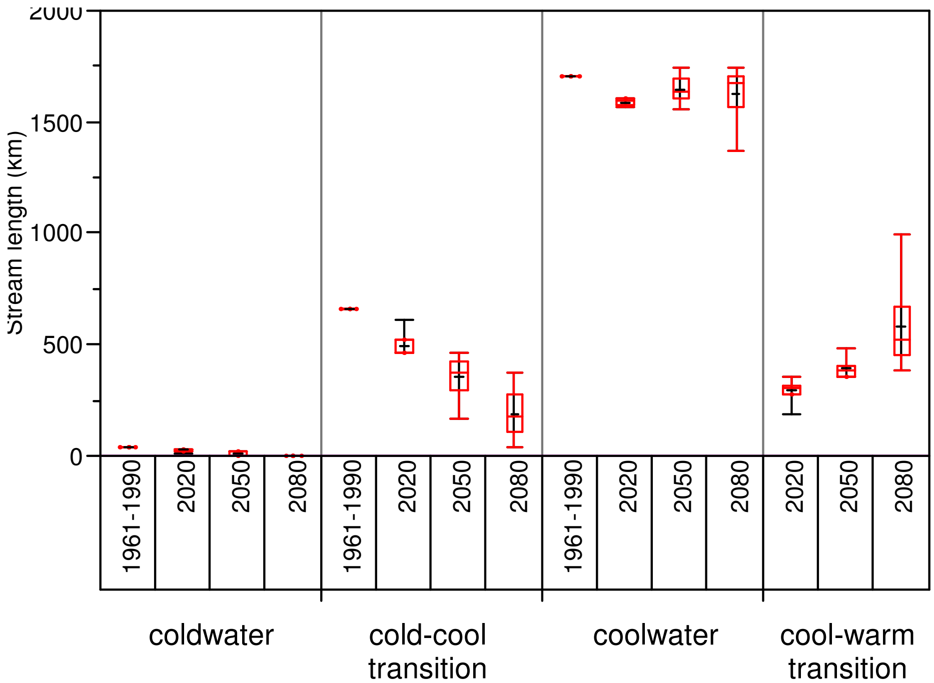

Figure 70. Linear extent (km) of thermal habitats across **West Road River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).

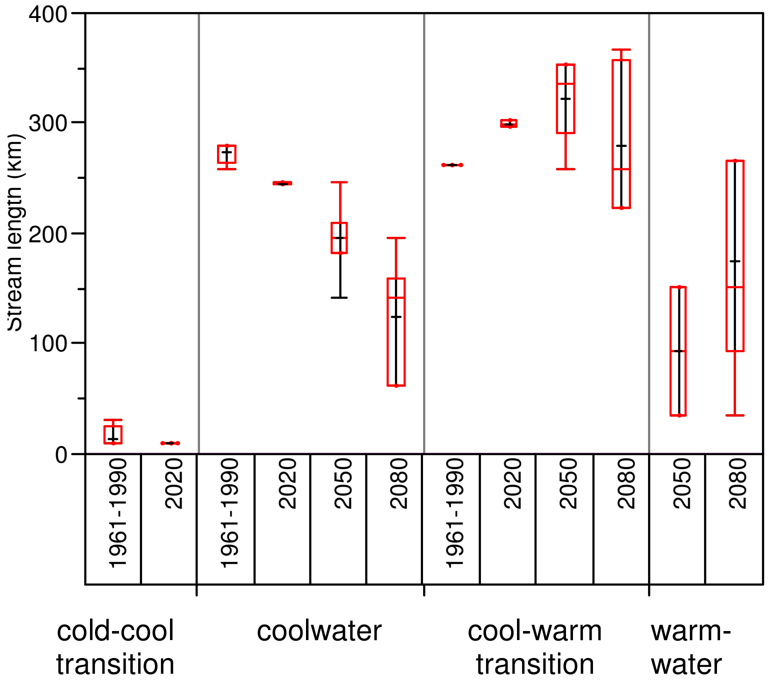

Figure 71. Linear extent (km) of thermal habitats across **Williams Lake River** watershed in a historic (1961-1990) and three future time periods (2020s, 2050s, and 2080s) under a range of climate change scenarios (box plots).