Competition & Hybridization and System Capacity

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Species Information

Common Name: Westslope Cutthroat Trout, Athabasca Rainbow Trout, Bull Trout
Genus: Oncorhynchus mykiss, Oncorhynchus lewisi, Salvelinus confluentus

Stressor Details

Stressor Name: Competition and hybridization
Units: % carrying capacity
Metric: Percent carrying capacity occupied by non-native species
Scale: linear
Function Type: continuous
Vital Rate/Process: System Capacity

Life Stage & Context

Life Stages: Adults
Geography: Rocky Mountains + foothill watersheds, Alberta

Descriptions

Overview

a. Competition by Non-Native Species
Brook Trout is a wide-spread, invasive species that may compromise populations of the three native trout species through competition (Warnock 2012, McMahon et al. 2007, Rieman et al. 2006, Peterson et al. 2008, 2004; Shepard et al. 2002, Magoulick and Wilzbach 1998; Popowich 2005; Donald 1987). If successful, Brook Trout may displace or replace, native salmonids (Behnke 1992; Peterson et al. 2004; Fausch 2007; McGrath and Lewis Jr. 2007; Peterson et al. 2008; Earle et al. 2010a, b).
While the mechanisms of non-native Rainbow Trout invasiveness have not been fully explored, it is assumed that niche overlap with Athabasca Rainbow Trout results in the replacement, but not displacement of the native trout species. In this theoretical framework, Athabasca rainbow trout are initially lost because of another threat (e.g., overfishing), and the direct stocking or migration of stocked Rainbows results in the replacement of native fish with non-native fish. This assumed no competitive advantage from non-native fish but is simply a factor of few native fish being in the area to allow a natural recovery, in area, versus abundant, locally stocked fish. This follows the overall theory of competition/replacement/exclusion of Volpe et al. (2000). At this time, there is no known system where native fish were abundant yet were replaced by non-native fish.
Competition only occurs when resources are limited, or the system is near carrying capacity (Dunham et al. 2002). Therefore, researchers should carefully examine available evidence to determine if Brook Trout, non-native Rainbow Trout or Lake Trout are competing with the three native trout species, or if they are taking advantage of resources made available as a result of declining native trout density due to other stressors (e.g., habitat changes, over-exploitation). Relatively high densities of Brook Trout, non-native Rainbow Trout or Lake Trout may indicate that the system is near or at carrying capacity, and therefore, competition may be occurring.
b. Hybridization
Currently there is an ongoing effort to understand the hybridization risk and extent of hybridization of Athabasca Rainbow Trout and non-native Rainbow Trout. Previous genetic sampling and analysis indicate that there are watersheds in the range that have only pure genetics while other watersheds contain a mix of pure and hybridized fish, this information will be refined using current genetic techniques and analysis.
The stressor-response curve to depict the impacts of competition and hybridization by non-native species on the three native trout species is a simple linear relationship between the ability of a system to hold adult native trout (system

capacity) and the capacity used by Brook Trout, non-native Rainbow, Lake Trout, and hybrids (carrying capacity). Native trout system capacity and non-native/hybridized trout carrying capacity must add to 100% (Figure 1). We have not accounted for the additional adverse effects of hybridization with pure native trout. Rather, this dose-response curve only accounts for competition and replacement related to habitat, so the true negative impacts of these non-native species is likely underestimated.

Function Derivation

expert opinion

Transferability of Function

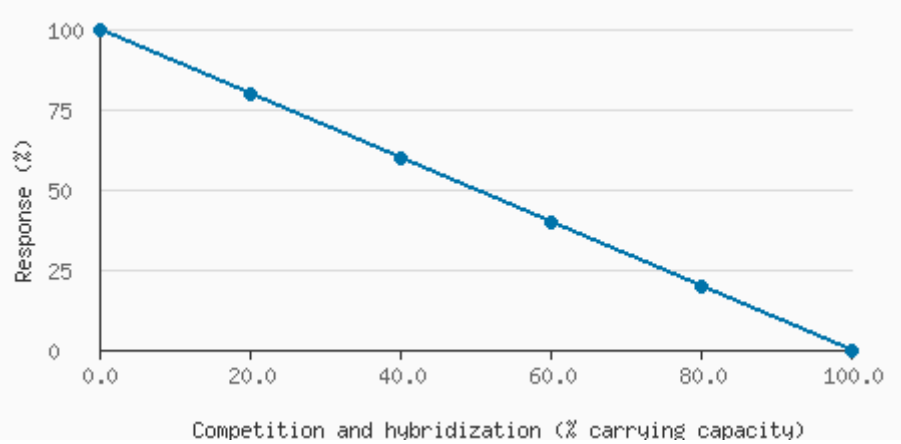
This function was developed and applied to Bull Trout, Athabasca Rainbow Trout, and Westslope Cutthroat Trout in Alberta foothills watersheds. Due to the theoretical nature of the relationship, it could be applied to other species and geographic areas with an acknowledgement of the lack of empirical data on which the function was built. If additional data is available for other systems, those should be incorporated.

Source of Stressor Data

Competition by Non-Native Species
Competition will be considered as occurring in stream reaches (order ?2) which once held or continue to hold the three native trout species, but now contain predominately Brook Trout or non-native Rainbow Trout at densities that suggest the system is at or near carrying capacity (estimated at approximately 80 Brook Trout or non-native Rainbow Trout / 300m, but can be dependent on stream size). Stream electrofishing survey data from FWMIS identified locations with high Brook Trout and non-native Rainbow Trout densities and then expert opinion was used to estimate the stream distance upstream and downstream from this location containing high Brook Trout and non-native Rainbow Trout densities.
Competition with Lake Trout was considered as occurring in lakes and reservoirs that once held or continue to hold Bull Trout, but now contain predominately Lake Trout at densities that suggest the system is at or near carrying capacity based on expert opinion. There are relatively few HUC10 watersheds where Lake Trout densities suggest competition may be occurring; these include the Middle Waterton River, Spray River and Abraham Lake watersheds.
The input value was the percentage of habitat occupied by Brook Trout, non-native Rainbow Trout and Lake Trout at hypothesized carrying capacity relative to the available native trout habitat within a watershed.

b. Hybridization
The amount of habitat in which non-native rainbow trout are replacing Athabasca Rainbow Trout was compared to historic Athabasca Rainbow Trout habitat in each HUC10 watershed. Replacement will be considered as occurring in streams and stream reaches (order ?2) which once held native rainbows, but now contain non-native Rainbow Trout. Using the available genetic data, stream segments identified as near pure (Qi=0.95-0.99) or hybrid (Qi

Stressor Response Data



?Non-Native Trout (% System Capacity)	Mean System Capacity (%)	SD	low.limit	up.limit	
0	100	0	0	100	
20	80	0	0	100	
40	60	0	0	100	
60	40	0	0	100	
80	20	0	0	100	
100	0	0	0	100	

Citations

Behnke, R.J. 2002. Trout and salmon of North America. The Free Press, New York. 359 p. Dunham, J., S.B. Adams, R.E. Schroetr, and D.C. Novinger. 2002. Alien invasions in aquatic ecosystems: Toward an understanding of brook trout invasions and potential impacts on inland cutthroat trout in western North America. Reviews in Fish Biology and Fisheries, 12: 373-391. Earle, J.E., A.J. Paul and J.D. Stelfox. 2010a. Quirk Creek population estimates and one-pass electrofishing removal of Brook Trout – 2009. Unpublished report, Fish and Wildlife Division, Alberta Sustainable Resource Development, Cochrane, Alberta. Earle, J.E., J.D. Stelfox and B.E. Meagher. 2010b. Quirk Creek Brook Trout suppression project – 2009. Unpublished report, Fish and Wildlife Division, Alberta Sustainable Resource Development, Cochrane, Alberta. Fausch, K. D. 2007. Introduction, establishment and effects of non-native salmonids: considering the risk of rainbow trout invasion in the United Kingdom. Journal of Fish Biology 71:1-32. Magoulick, Daniel & Wilzbach, Margaret. 1998. Effect of Temperature and Macrohabitat on Interspecific Aggression, Foraging Success, and Growth of Brook Trout and Rainbow Trout Pairs in Laboratory Streams. Transactions of The American Fisheries Society 127. 708-717. McMahon, T.E., A. V. Zale, F. T. Barrows, J.H. Selong, and R. J. Danehy. 2007. Temperature and Competition between Bull Trout and Brook Trout: A Test of the Elevation Refuge Hypothesis. Transactions of the American Fisheries Society 136:1313–1326. McGrath, C. C., and W. M. Lewis Jr. 2007. Competition and predation as mechanisms for displacement of greenback cutthroat trout by brook trout. Transactions of the American Fisheries Society 136:1381-1392. Peterson, D.P., K.D. Fausch, J.Watmough, and R.A. Cunjak. 2008. When eradication is not an option: Modeling strategies for electrofishing suppression of non-native Brook Trout to foster persistence of sympatric native Cutthroat Trout in small streams. North American Journal of Fisheries Management 28:1847-1867. Peterson, D.P., K.D. Fausch, and G.C. White. 2004. Population ecology of an invasion: Effects of brook trout on native cutthroat trout. Ecological Applications 14(3):754-772. Rieman, B., J. Peterson, and D. Myers. 2006. Have brook trout (Salvelinus fontinalis) displaced Bull Trout (Salvelinus confluentus) along longitudinal gradients in central Idaho streams? Canadian Journal of Fisheries and Aquatic Science 63:63-78. Shepard, B.B., R. Spoon, and L. Nelson. 2002. A native westslope cutthroat trout population responds positively after brook trout removal and habitat restoration. Intermountain Journal of Science 8:191-211. Warnock, W. 2012. Examining brook trout invasion into Bull Trout streams of the Canadian Rockies. PhD Thesis, University of Lethbridge, AB. 184 p.