Local-Habitat, Landscape, and Biotic Factors Associated with the Distribution of Hybridization Between Native Westslope Cutthroat Trout and Introduced Rainbow Trout in the Upper Flathead River System

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Invasion of nonnative fishes in freshwater systems is often facilitated through the interaction of environmental and biotic factors operating at multiple spatial and temporal scales. We evaluated the association of local-habitat features, large-scale landscape characteristics, and biotic factors with patterns of occurrence and degree of hybridization between native westslope cutthroat trout (*Oncorhynchus clarkii lewisi*; WCT) and nonnative rainbow trout (*O. mykiss*; RBT) in 35 streams of the upper Flathead River system in Montana., and British Columbia, Canada. The presence or absence of hybridization and the proportion RBT admixture for each sampled population was estimated using seven diagnostic microsatellite loci. Local-habitat features included measures of stream size, gradient, and elevation. Landscape variables included measures of mean and maximum summer water temperature and of land disturbance (upstream road density and the number of upstream road crossings). The abundance of trout within sampled sites and distance to the source of hybridization, e.g., Abbot Creek, were used as measures of the biotic potential for invasion to occur. We defined nine candidate logistic regression models that represented various combinations of these three factors and used an information-theoretic approach to evaluate the relative plausibility of competing models. Models combining local habitat (width) with landscape characteristics of mean summer temperature and number of road crossings in combination with the biotic variable distance to the source of hybridization were the most plausible models, yielding overall classification accuracies of about 88 percent. However, individual effects within these models could not be discerned because of collinearity. The presence of hybridization was positively associated with mean summer water temperature and number of upstream road crossings and negatively correlated with distance to the source of hybridization and stream width. Linear regression analyses showed that the distance to the source of hybridization was the only factor related to the proportion RBT admixture among hybridized sites. Finally, trout (> 75 mm) density was negatively related to stream width and elevation among the study streams. Our results suggest that hybridization increases in streams with warm water temperatures, high land use disturbance and close to the primary source of hybridization. Management strategies for preserving nonhybridized WCT populations should attempt to eradicate populations with high levels of RBT admixture in warmer streams with high densities of hybrid fish.