Appendix F

Validation and Application of Flow-Ecology Methods for Trout

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VALIDATION AND APPLICATION OF FLOW-ECOLOGY METHODS FOR TROUT

CONTENTS

INTRODUCTION

The purpose of this section is to review application of flow-ecology relationships for trout from (Wilding and Poff 2008) for the upper-Colorado basin. Specifically, how valid are the relationships when evaluated against independent datasets? This report focuses on Method 3 from (Wilding and Poff 2008), which provides a categorical rating of low flow suitability (Table 1).

Table 1 Method 3 reproduced from (Wilding and Poff 2008) for trout in Rocky Mountain streams. Categorical rating of low-flow suitability for trout (cutthroat, brook, brown and rainbow), from (Binns and Eiserman 1979). Summer flows (average for August to mid-September) are expressed as a percent of mean annual flow.

Rating	Summer low flow (% of mean ann. flow)	Description
0 (worst)	<10%	Inadequate to support trout.
1	10-15%	Potential for trout support is sporadic.
2	16-25%	May severely limit trout stock every few years.
3	26-55%	Low flow may occasionally limit trout numbers.
4 (best)	>55%	Low flow may very seldom limit trout.

VALIDATION OF FLOW-ECOLOGY RELATIONSHIPS

Validation of the Method 3 flow-ecology relationship was investigated using data from (Nehring 1979). In that report (Nehring 1979) compared the Montana method (Tennant 1976) to minimum flow recommendations based on R2-Cross and a pre-cursor method to PHABSIM (IFG4 is the hydraulic model implemented without a biological model). Sites included a wide range of Rocky mountain streams, with sixteen sites surveyed using R2-Cross and 14 using IFG4. Colorado basin sites included several on the Frying Pan, Williams Fork and Saint Louis. The minimum flows were based on similar objectives across methods (minimum water depths and/or velocities), with IFG4 producing minimum flow estimates based on more intensive sampling over the stream length and over time.

The R2-Cross method (single cross-section) estimates flows required to maintain depths sufficient to keep the largest fish wet as it swims through a riffle. Minimum flows produced using R2-Cross assessments averaged 28.4% of MAF, and IFG4 assessments averaged 27.9% of MAF (standard deviation 10.5% and 10.8% respectively). The surveyed minimum flows (R2-Cross and IFG4) were compared to the flow calculated as 25% of MAF for each site that was assessed by (Nehring 1979), and this relationship is presented in Figure 1. There is variability in the relationship with survey estimates, but the Method 3 approach provides a good approximation. The 25% of MAF distinguishes flows that "may severely limit trout" from flows that "may occasionally limit trout" (Table 1), so it seems appropriate for minimum flows based on the water depth required to keep a fishes back wet in riffles. The 25% threshold has appeared in many publications, which may have a common origin (earlier publications by Thomas Wesche).

The depth criteria used for R2-Cross, which dictated the recommended flow in most cases, was based on a sliding scale[1]. Therefore the indifference shown by the Method 3 to absolute stream size was effectively built into the R2-Cross assessments as well. (Nehring 1979) anticipated that R2-Cross would not be successful in predicting trout performance and recommended it for flow prescriptions on lower-value streams. The same study achieved good correlations with trout biomass using habitat suitability at MAF, using absolute depth-velocity criteria (i.e. not sliding scale) modeled in PHABSIM (termed IFG3 at the time), and he recommended this method for flow prescriptions on high-value fisheries.

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[1] Average riffle depth 1% of stream width for streams 20-100 feet wide, and 0.2 feet for smaller streams. Based on height of the largest fish present from tip of dorsal to lowest portion of body cavity.

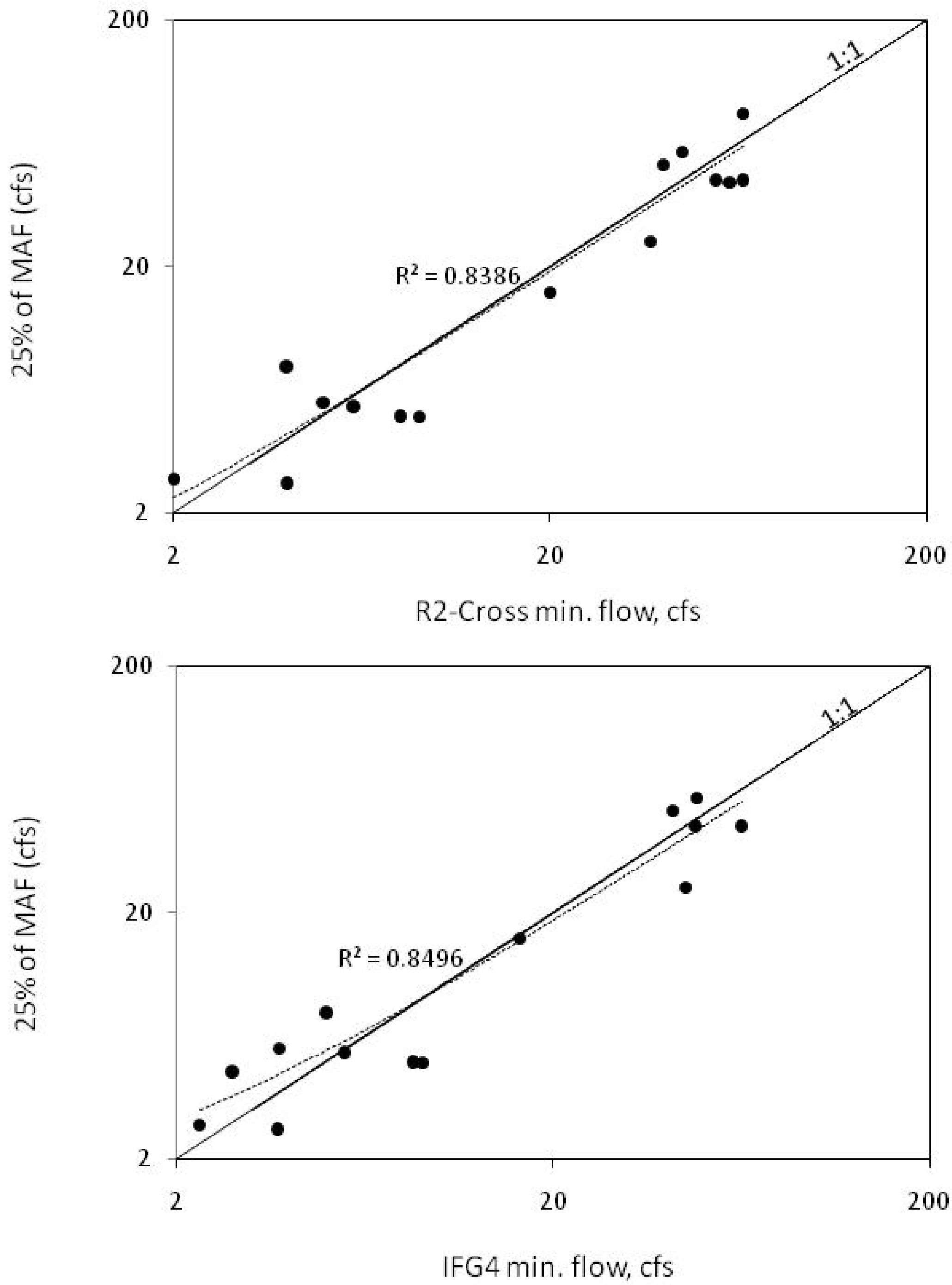

Figure 1 The relationship between 25% of MAF (threshold from Table 1) and minimum flows estimated using R2-Cross (upper plot) and a more intensive equivalent (IFG4 using similar depth targets – lower plot). The relationship (dashed line labeled with R^2 value for linear least squares) approaches the 1:1 relationship (solid line) expected if values were a match.

Additional validation of Method 3 was achieved by comparing predictions to Instream Flows from the Colorado Water Conservation Board (Water Division 5 – Upper Colorado River Basin). These allocations are typically based on R2-Cross assessments, but the final allocation likely incorporates other considerations, including water availability. There are additional complications in this comparison. To start with, the instream flows apply to long sections of stream, so it is not apparent whether any specific StateMod node corresponds to the survey point or points. There may also be several separate allocations that are not summed in this comparison. Automated GIS methods were not successful in matching Instream Flows to StateMod nodes for various reasons, so nodes were manually matched to instream flows. A subset of sites were randomly selected from the Division 5 summary (random selection stratified by 4 flow groups), producing 12 successful comparisons from 33 attempts (comparison not possible where nodes do not correspond or location descriptions were insufficient). The Method 3 prediction was again represented by the Category 2/Category 3 demarcation of 25% of natural MAF. Where instream flows varied seasonally, only the Instream Flow value that overlapped with the August-September period was used, as this is the period assessed using Method 3.

There is more variability in the relationship between the Instream Flows and Method 3 (Figure 2), compared to the Nehring results (Figure 1). But the Instream Flows approach 25% of MAF on average, as indicated by the regression line that lies close to the 1:1 line, and therefore provides further support for Method 3.

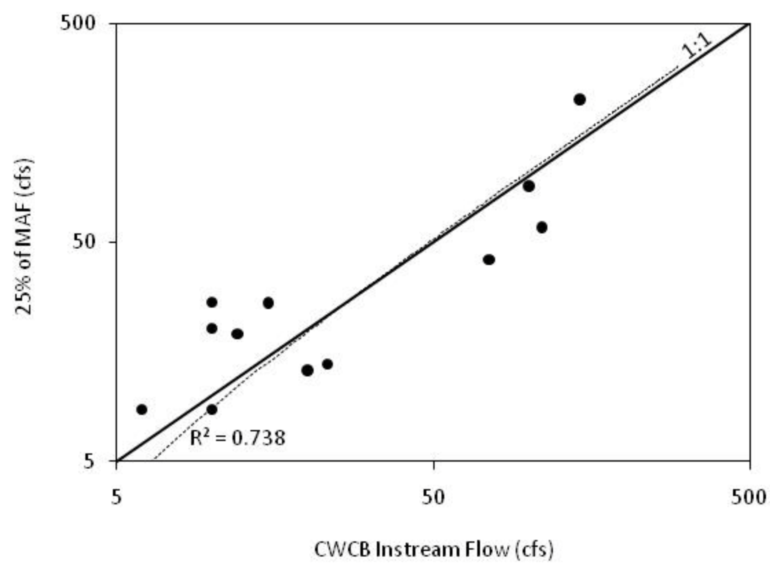

Figure 2 The relationship between 25% of MAF (threshold from Table 1) and Instream Flows allocated by the Colorado Water Conservation Board. The relationship (dashed line labeled with R^2 value for linear least squares) approaches the 1:1 relationship (solid line) expected if values were a match.

CUTTHROAT TROUT

An inability to reproduce successfully during short summers is expected to set the upper altitudinal limit for trout (Coleman and Fausch 2007). The order of cold-tolerance (stenothermy), from cold to warm is cutthroat, brook, rainbow and brown trout (Raleigh et al. 1986). The order of competitive advantage is the reverse, which often excludes cutthroat and brook trout from lower elevation waters where temperatures are otherwise tolerable (McHugh and Budy 2005). Self-sustaining populations of indigenous cutthroat trout (lacking hybrids) are typically isolated from introduced trout by instream barriers such as diversion structures (Young 1995, Young et al. 1996). The distribution of cutthroat trout is no longer the realization of suitable temperature and flow regimes, but instead tolerable refuges from introduced trout. This poses a more complex problem for predicting distribution. Direct mapping of conservation populations offers a better alternative to statistical modeling, given the small number of remaining populations and their well documented occurrence (Young et al. 1996).

The next question then is what relevance does Method 3 hold for these populations? Cutthroat trout are confined to small, high-elevation streams where they can avoid introduced trout, and these are places where both flow magnitude and stream temperature are expected to be marginal. This was demonstrated by (Harig and Fausch 2002), with a high chance of failure of translocated cutthroat trout in small streams with cold summer water temperatures. Several studies have demonstrated the greater proportion of mean flow required to maintain trout habitat in smaller streams (Hatfield and Bruce 2000, Lamouroux and Jowett 2005). Therefore, it is reasonable to assume that stream flow is a limiting factor for remaining cutthroat trout populations. It is worth clarifying that flow is not the primary limiting factor - clearly barriers to invasion from introduced trout are of primary importance for persistence of conservation populations. Rather it implies that flow acts to constrain populations of cutthroat trout in the small streams that lack introduced trout.

The study by (Binns and Eiserman 1979), upon which Method 3 was based, certainly includes many small streams (MAF not provided for all sites, but 20% of sites were < 3m wide during summer), so is at least relevant. The study by (Nehring 1979) has already provided some validation of the 25% of MAF threshold for smaller streams that support cutthroat trout, based on R2-Cross predictions (see the section Validation of flow-ecology relationships). What's missing is population level validation specifically for cutthroat trout in small streams. But effort may be better invested in site specific investigations, and there are several reasons for this. The values and objectives associated with conservation of cutthroat trout differ to management of recreational fisheries. The flows required to ensure that a population persists are likely less than the flows required to support a gold medal fishery, but flow is more severely limiting in the small streams where cutthroat are now confined. (Young 1995) cited a Wyoming study where most populations of cutthroat persisted in streams less than 0.85 m^3/s (mean annual flow, cf. Figure 2). Additionally, the limited distribution of cutthroat trout reduces the value of regional methods - (Young et al. 1996) reported 9 “conservation populations” and ~70 compromised populations in the upper Colorado basin. Method 3 will at least provide a basin level picture of where reduced flows coincide with cutthroat trout populations and aid in prioritizing such assessments.

RECOMMENDATIONS

The area of application was not evaluated in this report as the Colorado Division of Wildlife has provided advice on this matter. This report instead focused on validation of Method 3 using physical data including R2-Cross surveys, more intensive surveys pursuing similar flow targets and Instream Flows that are in some way based on R2-Cross surveys. These support Method 3 as providing an adequate approximation of R2-Cross predictions at least for the purposes of basin wide planning assessments. The method is not expected to provide an adequate substitute for site-specific flow prescriptions, particularly where cutthroat trout populations of conservation value are concerned, or valued recreational fisheries.

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