Factors Influencing Distributions of Salmonids in the Little Bighorn River Drainage, Wyoming

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Abstract

We assessed the influences of geomorphology and introductions of nonnative salmonid species on the distributions of salmonids in headwater streams of the Bighorn Mountains in Wyoming. We sampled geomorphic features and fish at 71 sites among streams in four watersheds near the headwaters of the Little Bighorn River in 1999. Brook trout *(Salvelinus fontinalis)*, rainbow trout *(Oncorhynchus mykiss)*, cutthroat trout *(O. clarki)*, and cutthroat trout x rainbow trout hybrids were found in the study area. Distributions were influenced by stream size, channel slope, natural barriers to upstream movement by salmonids, spatial patterns of nonnative salmonid introductions, and recent stocking of nonnative salmonid species. Salmonids were found at sites with wetted widths $\geq$ 1.1 m and channel slopes $\leq$ 16 percent, and the probability of salmonid presence increased as wetted width increased and channel slope decreased. Natural barriers to upstream movement appeared to have excluded nonnative salmonids from colonizing some small headwater streams. Two allopatric populations of genetically pure Yellowstone cutthroat trout were isolated from nonnative salmonids by natural barriers. Past introductions of brook trout and rainbow trout haves led to naturalized populations in large portions of the study area. Recent stocking of cutthroat trout and rainbow trout accounted for occurrence of these species in some headwater streams where evidence of natural reproduction was not found.

Key words: Salmonidae, trout, mountains, streams, geomorphology, native fishes, introduced fishes, Bighorn Mountains, Big Horn National Forest

Introduction

A focus of fisheries science in the Intermountain West is on the decline of native cutthroat trout (*Oncorhynchus clarki*) with substantial research being directed toward understanding their habitat requirements and the influences of anthropogenic activities (Hildebrand and Kershner 2000, Kruse et al. 2000). Cutthroat trout occupied the widest natural geographic distribution of any Salmonidae in the United States (Behnke 1992). The Yellowstone subspecies (*O. c. bouvieri*) had a wide range occupying the Yellowstone River drainage in Montana and Wyoming, including the Little Bighorn River drainage in Montana and Wyoming, and the Snake River drainage downstream to Shoshone Falls in Idaho (Varley and Gresswell 1988, Behnke 1992). However, the distribution of Yellowstone cutthroat trout has declined substantially since settlement by Europeans (Varley and Gresswell 1988, Kruse et al. 2000).

Fisheries scientists are adopting the watershed as their scale for research and management (Wesche and Isaak 1999) and the effects of spatial habitat patterns on salmonid distributions at this scale are becoming more evident (Meehan 1991). For example, Kruse et al. (1997) identified watershed-scale geomorphic features that affected the distributions of Yellowstone cutthroat trout in the Absaroka Mountains, Wyoming. They found that channel slope, elevation, stream size, and barriers to upstream movement significantly influenced the presence and absence of Yellowstone cutthroat trout where nonnative salmonid species did not occur. Nevertheless, the effects of geomorphic features on either native cutthroat trout or nonnative species of salmonids are not well defined.

Numerous anthropogenic activities are affecting native cutthroat trout in the Intermountain West (Meehan 1991, Young 1995), but the most extensive may be the introduction of nonnative salmonid species (Varley and Gresswell 1988, Behnke 1992). Brook trout (*Salvelinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*), and brown trout (*Salmo trutta*) have been widely introduced and have become naturalized in many montane stream systems, contributing to declines of native cutthroat trout through competition and hybridization (Griffith 1972, DeStaso and Rahel 1994, Henderson et al. 2000, Kruse et al. 2000, Novinger 2000).

The salmonid assemblages in streams of the Bighorn Mountains in northern Wyoming probably are representative of many montane stream systems throughout the Intermountain West. Fisheries management in the Bighorn Mountains during much of the last century focused on introductions of nonnative salmonids to expand distributions and enhance sport fisheries because most headwater streams and alpine lakes of the Bighorn Mountains had no natural salmonid populations. Consequently, distributions and species assemblages of salmonids have been substantially altered by management activities.

Our objectives were to describe the current distributions of salmonid species in montane portions of the Little Bighorn River drainage in Wyoming and to assess geomorphic and anthropogenic factors that influence distributions. Geomorphic factors included elevation, stream width, channel slope, and natural barriers to upstream movements by salmonids, and anthropogenic factors included past introductions and recent stockings of nonnative salmonids.

Study Area and Methods

The Bighorn Mountains are approximately 120 km long and 50 km wide with elevations of 1650-3950 m above mean sea level (Lageson and Spearing 1988). The mountain range is almost totally encompassed by the Big Horn National Forest. Primary land uses are recreation, livestock grazing, and some timber harvest.

The anticlinal uplift of the Bighorn Mountains consists of a granitic core covered with sedimentary limestone and dolomite. The uplift created a plateau-like geomorphology that affects the longitudinal profile of many headwater streams. Many headwater streams originate from springs or alpine lakes near the base of the granitic core, cross subalpine meadows on the plateau, and flow through steep, deeply incised canyons before emerging onto the plains at the base of the mountains. In many streams the upstream movement of fish onto the plateau is blocked by falls and cascades in the canyons.

The Little Bighorn River drainage is at the northern end of the Bighorn Mountains (Fig.1). Four headwater watersheds converge near the northern edge of the Big Horn National Forest and the Montana-Wyoming state line to form the mainstem of the Little Bighorn River that flows north into the Yellowstone River. Falls and cascades in deeply incised canyons near the downstream ends of three (West Fork Little Bighorn River, Upper Little Bighorn River, and Dry Fork Little Big Horn River) of four watersheds are believed to have prevented natural colonization of these watersheds by Yellowstone cutthroat trout.

Perennial streams identified on U.S. Geological Survey, 1:24,000-scale topographic maps were sampled during summer 1999 in the headwaters of the Little Bighorn River. Sampling sites at about 1.5-km intervals were selected for sampling. Sampling progressed upstream in small headwater streams until no fish were found. If we encountered a probable barrier to upstream movement by salmonids, a site was sampled immediately upstream. Probable barriers were defined as channel-

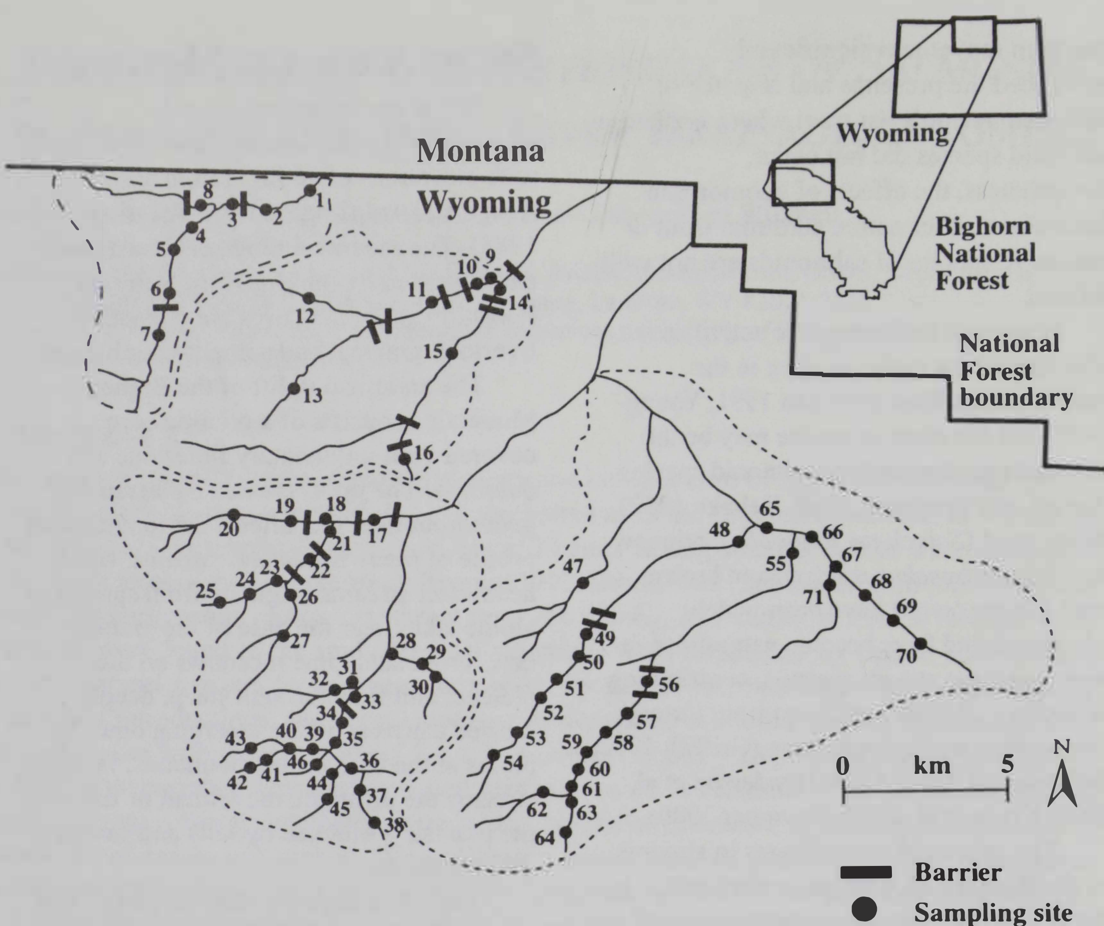

Figure 1. Map of the Little Bighorn River drainage in Wyoming showing the four watersheds within the drainage. Numbers indicate locations of sampling sites described in Table 1.

wide falls created by rock formations at least 1.5 m high (Stuber et al. 1988) or as steep (> 30% channel slope) cascades >15 m in length. Locations of barriers were identified on topographic maps. Because of the inaccessibility of some steep-walled canyons, some selected sampling sites could not be sampled.

Fish were sampled by electrofishing a 100-m reach at each accessible site. Two or three electrofishing passes were made progressing upstream and all stunned fish were collected and released. Captured fish were identified to species using morphological features (Baxter and Simon 1970). Spotting patterns, throat slashes, and white fin margins were used to identify cutthroat trout x rainbow trout hybrids in the field (Kruse 1998).

Elevation, channel slope, and wetted width were determined at each sampling site. Elevation was estimated using 1:24,000-scale topographic maps at the midpoint of the 100-m fish-sampling reach. An Abney level was used to measure channel slope of the reach (Isaak et al.1999). Individual habitat units (cascades, riffles, glides and pools) were identified over the length of each reach (Bisson et al.1982) and the length of each habitat unit was measured. Wetted width was measured perpendicular to streamflow at the midpoint of each habitat unit. We used habitat unit lengths and wetted widths to compute a weighted average wetted width for each reach.

Wyoming Game and Fish Department files in the Sheridan Regional Office were reviewed for stocking records of salmonids within the Little Bighorn River drainage.

We obtained information on species, stocking locations, and tocking dates. At sampling sites where allopatric populations of cutthroat trout were found and there were no records of recent stocking, a portion of the upper lobe of the caudal fin was removed from each cutthroat trout and preserved in ethanol. Genetic analysis of the caudal fish tissue was conducted at the Brigham Young University Fish Genetics Laboratory, Provo, Utah. Two mitochondrial DNA markers were identified through DNA restricted fragment analysis and compared to an existing library of cutthroat trout DNA fragment patterns. Two nuclear-based DNA markers were isolated from the internal transcriber spacer region of ribosomal DNA and compared to other cutthroat trout samples. In combination, these four markers are believed to provide an accurate appraisal of introgression between cutthroat trout and rainbow trout (Billington and Hebert 1991).

Evidence of natural reproduction was used as an index of naturalization of introduced species. Recently stocked salmonids exceeded 100 mm TL at the time of stocking (Wyoming Game and Fish Department, Sheridan Regional Office, file records). Consequently, the presence of fish < 100 mm TL at a site provided evidence of natural reproduction.

Multiple-logistic regression was used to assess the influence of geomorphic features on the presence/absence of salmonids (Ramsey and Schafer 1997). The form of the logistic function is

$$P = \exp^{u}/(1 + \exp^{u})$$

where P = the estimated probability, exp = base of the natural logarithm (i.e., 2.718), and u = the linear model

$$u = A + b_1X_1 + b_2X_2 + \ldots + b_nX_m$$

where A = regression constant, b_n = regression coefficients, and X_m = independent variables. Significance of models and individual independent variables was assessed using Chi-square tests (a = 0.05). The goodness of fit of each model was evaluated using the Hosmer-Lemeshow statistic with values $\geq$ 0.5 considered satisfactory (Ramsey and Schafer 1997). Because sampling sites were selected to be representative of the population of possible sampling sites, different response outcomes could have occurred with different sets of sites. Consequently, probabilities cannot be estimated from such retrospective samples, but odds ratios can be estimated and used to assess the influence of variation in independent variables on the odds of presence of salmonids (Ramsey and Schafer 1997). We used Statistix for Windows (Analytical Software 1996) to compute the logistic regressions.

Results

Geomorphic Factors

Seventy-one sites were sampled across the Little Bighorn River drainage on the Big Horn National Forest (Table 1, Fig. 1). Sampled sites ranged from 1695 to 2792 m above mean sea level with wetted widths of 0.6-6.9 m and channel slopes of 1.0-25.0 percent. Brook trout, rainbow trout, cutthroat trout, or cutthroat trout x rainbow trout hybrids alone or in various combinations were found at 51 sites over the entire range of elevations sampled. No salmonids were found at sites with wetted widths < 1.1 m or channel slopes > 16 percent (14% of sampled sites).

We identified 22 barriers to upstream salmonid movement across the headwaters of the Little Bighorn River drainage (Fig. 1), three in the Lodgegrass Creek watershed, nine in the Pumpkin Creek watershed, six in the Upper Little Bighorn River watershed, and four in the Dry Fork Little Bighorn River watershed. We found no salmonids upstream from some barriers in the headwaters of Lodgegrass (Fig. 1, site 7), Pumpkin (sites 11 and 12), Cub (site 13), Mann (sites 15 and 16), and Wagonbox (sites 19 and 20) creeks. Wetted widths were 2.3-4.1 m and channel slopes were 2.5-15.5 percent among these eight sites, within the ranges of wetted widths and channel slopes occupied by salmonids at other sites in the study area. Consequently, we assumed that barriers to upstream movement had prevented these eight sites from being colonized by salmonids.

Table 1. Sites sampled in the headwaters of the Little Bighorn River watershed on the Bighorn National Forest in Wyoming during 1999. Site numbers correspond with locations on Figure 1. Species found included rainbow trout (RBT), cutthroat trout (CUT), brook trout (BKT), and cutthroat trout x rainbow trout hybrids (CUT x RBT). Underline of species acronym indicates that evidence of natural reproduction was observed.

Stream	Site	Elevation (m)	Wetted width (m)	Channel slope (%)	Species found
	Lodgegrass Creek Drainage				
Lodgegrass Creek	1	1,957	4.7	14.0	RBT, CUT x RBT
	2	2,030	4.3	15.0	RBT, CUT, CUT x RBT
	3	2,073	4.6	15.5	CUT
	4	2,256	4.2	11.5	CUT
	5	2,304	4.4	7.0	CUT
	6	2,374	4.1	10.5	CUT
	7	2,414	4.1	19.0	
Line Creek	8	2,226	4.1	25.0	
	West Fork Little Bighorn River Drainage				
Pumpkin Creek	9	1,695	4.2	7.5	CUT
	10	1,707	4.3	8.0	CUT
	11	1,774	4.1	14.5	
	12	2,060	3.6	12.0	
Cub Creek	13	2,195	3.0	15.5	
Mann Creek	14	1,695	3.8	13.0	CUT
	15	1,829	3.2	20.0	
	16	2,121	2.3	16.0	
	Upper Little Bighorn River Drainage				
Wagonbox Creek	17	2,176	3.9	7.0	BKT
	18	2,274	5.0	16.0	BKT
	19	2,390	3.1	2.5	
	20	2,536	2.3	9.5	
Duncum Creek	21	2,274	3.4	12.5	BKT
	22	2,432	4.1	4.0	BKT
	23	2,512	3.1	4.0	BKT
	24	2,579	2.9	13.0	BKT
	25	2,640	1.0	8.5	
Duncum Creek Tributary	26	2,505	3.1	4.5	BKT
	27	2,609	2.4	3.5	BKT
Dayton Gulch	28	2,536	2.2	2.4	CUT, BKT
	29	2,597	2.1	2.5	BKT
	30	2,621	1.3	2.5	
Half Ounce Creek	31	2,536	3.1	2.5	CUT, BKT
	32	2,548	1.4	2.0	BKT
Little Bighorn River	33	2,548	5.8	2.5	BKT
	34	2,576	6.1	3.5	BKT
	35	2,633	6.4	1.5	CUT, BKT
	36	2,682	2.3	3.0	CUT, BKT
	37	2,719	1.6	2.0	CUT
	38	2,758	1.0	7.0	
Little Bighorn River Tributary 1	39	2,670	3.5	11.0	CUT, BKT
	40	2,707	2.6	5.0	CUT, BKT
	41	2,792	1.5	2.5	BKT
	42	2,792	1.1	2.5	BKT

Table 1. Continued.

Stream	Site	Elevation (m)	Wetted width (m)	Channel slope (%)	Species found
Little Bighorn River Tributary 2	43	2,780	1.8	2.0	BKT
Little Bighorn River Tributary 3	44	2,688	2.0	10.5	BKT
	45	2,749	1.0	7.5	
Little Bighorn River Tributary 4	46	2,658	1.2	6.5	CUT, BKT
	Dry Fork Little Bighorn River Drainage				
Beartrap Creek	47	2,402	0.6	19.0	
Lick Creek	48	1,981	4.2	10.0	RBT, CUT, CUT x RBT
	49	2,499	3.9	16.0	CUT
	50	2,548	4.8	14.0	CUT
	51	2,597	3.8	2.5	CUT
	52	2,621	2.7	2.5	CUT
	53	2,694	2.8	1.0	CUT
	54	2,731	2.2	4.5	
Lake Creek	55	1,975	4.4	3.0	RBT
	56	2,403	3.3	11.5	
	57	2,499	4.0	2.5	RBT, BKT
	58	2,524	5.0	8.0	BKT
	59	2,597	3.1	5.0	RBT
	60	2,627	2.9	3.0	RBT
	61	2,658	1.9	2.0	RBT
	62	2,706	1.4	2.0	
Ice Creek	63	2,646	2.0	4.0	RBT
	64	2,731	1.6	4.0	
Dry Fork	65	1,878	6.9	4.0	RBT, BKT
	66	1,923	5.4	5.0	RBT, BKT
	67	1,963	4.4	6.5	BKT
	68	2,006	4.4	5.5	BKT
	69	2,060	2.1	7.0	BKT
	70	2,109	1.0	4.5	
Garland Gulch	71	2,402	2.2	4.5	

Wetted width and channel slope in separate models each accounted for presence/absence of salmonids among the 71 sites (Table 2). The wetted width equation indicated that probability of salmonid presence increased as wetted width increased. This equation had a high rate of correct classification for sites where occurrence of fish was predicted (90%), but it was not as good for sites where we predicted an absence of fish (38%). Conversely, the channel slope equation indicated that the probability of salmonid presence decreased as channel slope increased. Correct classification rates were similar to the wetted width model.

When the eight headwater sites assumed to be isolated by barriers to upstream movement by salmonids were removed from the data set, wetted width alone and a model with both wetted width and channel slope accounted for presence/absence of salmonids and the rates of correct predictions were enhanced (Table 2).

No significant logistic regression equations that fit the logistic model were found that accounted for presence/absence of individual salmonid species.

Nonnative Salmonids

Wyoming Game and Fish Department records indicated past introductions as well as recent stockings of nonnative salmonids over a large portion of the Little Bighorn River drainage. Brook trout were introduced in the Lodgegrass Creek watershed in 1953, in the Upper Little Bighorn River watershed in 1945, and in the Dry Fork Little Bighorn River watershed in 1950, 1951, 1956, and 1960. Rainbow trout were introduced in the Lodgegrass Creek watershed in 1938, 1939,

Table 2. Logistic regression models with significant geometric variables, correct classification rates, Hosmer-Lemeshow (H-L) statistics, and odds rations predicting presence or absence of salmonid fishes in montane streams of the Little Bighorn River drainage in northern Wyoming.

Model parameters	Value (SE)	*P*	Number of cases	Classification percent (present/absent/overall)	H-L	Odds ratio
Models with all sites						
Constant	-1.188 (0.69)	0.0857	71	90/38/75	9.62	
Wetted width	0.710 (0.24)	0.0027				2.03
Constant	2.060 (0.53)	0.0001	71	92/33/74	7.64	
Channel slope	-0.149 (0.05)	0.0043				0.86
Models without isolated headwater sites						
Constant	-1.666 (0.85)	0.0507	63	94/54/86	8.91	
Wetted width	1.187 (0.37)	0.0012				3.28
Constant	-1.157 (0.96)	0.2301	63	94/54/86	8.18	
Wetted width	1.674 (0.50)	0.0009				5.33
Channel slope	-0.251 (0.11)	0.0248				0.78

1942, and 1944, and in the Dry Fork Little Bighorn River watershed in 1937 and 1944. Between 1985 and 1995 rainbow trout were stocked annually near the headwater of Lake Creek in the Dry Fork Little Bighorn River watershed. Stocking of cutthroat trout from hatcheries took place in the Lodgegrass Creek watershed in 1945, 1956, and 1958, in the West Fork Little Bighorn River watershed in 1946, in the Upper Little Bighorn River watershed in 1946 and through the 1990s, and in the Dry Fork Little Bighorn River watershed in 1940, 1958, 1960, 1966-1969, and every 1-4 years after 1976. Between 1985 and 1999 cutthroat trout stocking in the Dry Fork Little Bighorn River watershed was exclusively within the headwater of Lick Creek.

Distribution patterns of nonnative salmonids in 1999 were related to past introductions across the Little Bighorn River drainage (Table I). Brook trout were found throughout the Upper Little Bighorn River watershed and much of the of the Dry Fork Little Bighorn River watershed, both of which received introductions of brook trout between 1945 and 1960. However, no brook trout were found in the Lodgegrass Creek watershed, despite the record of an introduction in 1953. Rainbow trout were found downstream from a barrier in Lodgegrass Creek (sites 1 and 2) and at several locations in the Dry Fork Little Bighorn River watershed. Rainbow trout had not been stocked in the Lodgegrass Creek watershed since 1944, but they had been stocked in the Dry Fork Little Bighorn River watershed as recently as 1995. Cutthroat trout were found throughout the Little Bighorn River study area, but there were records of past stocking of cutthroat trout from hatcheries in all four of the watersheds within the study area. Cutthroat trout x rainbow trout hybrids were observed downstream from a barrier in Lodgegrass Creek (sites 1 and 2) and at the most downstream site in Lick Creek (site 48), sites where both cutthroat trout and rainbow trout also were found.

Natural Reproduction

Evidence of natural reproduction by salmonid species varied across the Little Bighorn River drainage (Table 1). We found evidence of natural reproduction by cutthroat trout only in the upstream portion of Lodgegrass Creek (Fig. I, sites 3 and 4) and near the junction of Pumpkin and Mann creeks (sites 9, 10 and 14) where cutthroat trout were allopatric. Rainbow trout reproduction was evident only in the downstream portion of Lodgegrass Creek (sites 1 and 2), Lake Creek (site 55), and the Dry Fork Little Bighorn River (sites 65 and 66). Occurrence of cutthroat trout x rainbow trout hybrids in the downstream portion of Lodgegra s Creek (sites 1 and 2) and at the most down tream site on Lick Creek (site 48) in the Dry Fork Little Bighorn River drainage indicated natural reproduction by *Oncorhynchus* in the vicinity of these stream reaches. Brook trout reproduction was indicated throughout the Upper Little Bighorn River and Dry Fork Little Bighorn River watersheds.

Cutthroat Trout

Barriers to upstream movement of salmonids on Lodgegrass (downstream from site 3) and Pumpkin-Mann (downstream from sites 9 and 14) creeks isolated allopatric, genetically pure populations of cutthroat trout. Mitochondrial and nuclear DNA analysis of 21 fish from the upstream portion of Lodgegrass Creek and 24 fish from near the confluence of Pumpkin and Mann creeks indicated that both populations were genetically pure Yellowstone cutthroat trout (Evans and Shiozawa 2000).

Where cutthroat trout were found in other portions of the Little Bighorn River drainage, they unlikely were genetically pure Yellowstone cutthroat trout endemic to the drainage. Genetic analysis was not conducted for samples of cutthroat trout from most sites where they were found because of visual evidence of hybridization with rainbow trout or knowledge of recent stocking of cutthroat trout at or near these sites. Cutthroat trout at the downstream ends of Lodgegrass Creek (sites I and 2) and Lick Creek (site 48) were found in association with reproducing rainbow trout and cutthroat trout x rainbow trout hybrids indicating that the cutthroat trout in these reaches were part of an integrated *Oncorhynchus* population. Additionally, cutthroat trout at sites in the Upper Little Bighorn River and Dry Fork Little Bighorn River drainages showed no evide,1ce of natural reproduction and their distributions were associated with locations of recent stockings of cutthroat trout by the Wyoming Game and Fish Department.

DISCUSSION

Stream size, channel slope, and barriers to upstream movement interact to limit the distributions of salmon ids (Nelson et al. 1992, Kruse et al 1997). We found no salmonids at sites <1.1 m wide or having channel slopes > 16 percent in the Little Bighorn River dramage, features characteristics of headwaters of many montane stream systems (Kruse et al. 1997, Kruse 1998). Logistic regression indicated an increasing probability of occurrence of salmonid as wetted width increased and as channel slope decreased. We found no salmonids upstream from barriers near the headwater of several streams originating in steep valleys. While the streams at the e sites were of moderate size (2.3-4.1 m wide), channel slopes tended to be relatively high (2.5-19.0 percent). Kruse et al. (1997) found sites with cutthroat trout had wetted widths >1.3 m and channel slopes of< 17 percent in the Absaroka Mountains of northwestern Wyoming, similar to our observations for salmonids in the Little Bighorn River drainage. Cutthroat trout were rarely found in streams with channel slopes >10 percent in the Absaroka Mountains (Kruse et al. 1997), but we found cutthroat trout at several sites with channel slopes of 10-16 percent.

Two allopatric, reproducing cutthroat trout populations were found in the Little Bighorn River drainage, one in the up tream portion of Lodgegra s Creek (Fig I, sites 3-6) and a second in the vic101ty of the confluence of Pumpkin and Mann creeks (ites 9, IO and 14). The population in the headwaters of Lodgegrass Creek likely was native to the dramage as we found no evidence of past stockmg, and these fish differed somewhat from hatchery stock in Yellow tone Lake widely used in Wyoming (Evans and Shiowaza 2000) However, genetic analysis suggested that the Pumpkin-Mann creek population wa similar to fish from Yellowstone Lake (Evans and Shiozawa 2000), a source of hatchery stock used by many management agencies (Varley and Gresswell 1988) including the Wyoming Game and Fish Department. Results of this analysis suggested that this population was the result of the 1946 introduction. An endemic population of Yellowstone cutthroat trout likely did not occur in Pumpkin-Mann creeks because waterfalls and cascades downstream in Pumpkin Creek and West Fork Little Bighorn River probably prevented natural colonization. Similarly, waterfalls and cascades near the downstream ends of the Upper Little Bighorn River and Dry Fork Little Bighorn River watersheds probably prevented natural colonization from downstream by Yellowstone cutthroat trout. Salmonid species found in these two watersheds in 1999 were likely to be the products of past and recent stocking. However, given the history of stocking, it cannot be determined if natural populations of Yellowstone cutthroat trout may have occurred in any of these watersheds.

Introductions of nonnative salmonids in the Little Bighorn River drainage began in 1933 and stocking continues to affect fish distributions. These activities appear to have extended distributions of salmonid species and diversified salmonid assemblages in these streams, similar to other locations in the western United States (Krueger and May 1991, Li and Moyle 1999). Naturalized populations of brook trout now occur throughout the Upper Little Bighorn River and Dry Fork Little Bighorn River watersheds, but brook trout were not found in Lodgegrass Creek despite an introduction in I 953. Two naturalized populations of rainbow trout occurred in the drainage in the downstream portion of Lodgegrass Creek (Fig. I, sites I and 2) and in the Dry Fork Little Bighorn River and downstream portions of Lake and Lick creeks (sites 48, 55, 65 and 66). Both naturalized rainbow trout populations occurred at low elevations (<2030 m) in reaches that are relatively wide (4.3-6.9 m wetted width) compared to the array of streams in the montane portion of theLittle Bighorn River drainage. Recent stockings of rainbow trout near the headwaters of Lake Creek (Fig. 1, sites 57-61) and of cutthroat trout near the headwaters of Lick Creek (sites 49-53) appeared to be the sources of the populations of these species observed in 1999. We found no evidence of natural reproduction by rainbow trout or cutthroat trout in these headwater areas. The sites in Lake Creek were at elevations of 2499-2658 m and had wetted widths of 1.9- 4.0 m. Similarly, sites on Lick Creek were at elevations of 2499-2694 m and had wetted widths of 2.8-3.9 m. Observations by Wyoming Game and Fish Department personnel (Dey and Annear 1993) and us suggest that availability of suitable spawning gravel limits reproduction in these tributaries. Gravel is relatively rare and where it occurs it tends to be highly embedded with sediment and calcium carbonate deposits that cement the rocks together.

Geomorphic features combine with past introductions and recent stockings of nonnative salmonids to affect distributions of salmonid species in the Little Bighorn River drainage. Nonnative salmonids probably have moved upstream from low-elevation introduction sites to colonize many headwater streams where barriers to upstream movement are not present. Fish are present in these headwater sites because recolonization from downstream source populations is possible following stochastic events, such as drought, floods, or severe winters, that may periodically decimate fish populations (Kruse et al. 200 I). Several headwater streams do not have fish in them because barriers have prevented colonization from downstream. However, introductions of cutthroat trout or nonnative species upstream from barriers in small, high-gradient headwater streams, e.g., sites in the headwaters Lodgegrass, Pumpkin, Mann, and Wagonbox creeks, would unlikely result in naturalized populations because of limited space, lack of spawning and nursery habitat, and stochastic events that periodically decimate populations (Lamberti et al. 1991, Hildebrand and

Kershner 2000). Due to topography of some of the Upper Little Bighorn River and Dry Fork Little Bighorn River watersheds, sources of nonnative salmonids occur in low- to moderate-gradient headwater streams at high elevations. Recently stocked cutthroat trout or rainbow trout and naturalized brook trout in these headwaters are likely to contribute recruits to downstream areas. Some fish from these stocks probably migrate downstream over barriers, provide a degree of continuity with downstream source populations, and enable salmonids to occur in relatively high-gradient reaches where stochastic events eliminate fish relatively frequently.

Our findings tend to confirm the belief that almost all of the Little Bighorn River drainage was naturally void of native cutthroat trout. Only one small population in the headwaters of Lodgegrass Creek is likely to be native; consequently, conservation efforts should be directed toward that population. The potential exists to create naturalized, allopatric populations of genetically pure Yellowstone cutthroat trout in other portions of the drainage, as apparently happened at the juncture of Pumpkin and Mann creeks. Some headwater streams upstream from natural barriers, currently void of salmonids, may be large enough to support introduced cutthroat trout populations, but most are probably too small or lack sufficient habitat diversity to sustain populations over the long term. Most of the streams in the drainage harbor naturalized populations of exotic salmonids that would require removal prior to cutthroat trout introductions. Also, a lack suitable spawning habitat may discourage naturalization of stocked cutthroat trout in most headwater streams.

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