Restoration of Fluvial Arctic Grayling to Montana Streams: Assessment of Reintroduction Potential of Streams in the Native Range, the Upper Missouri River Drainage above Great Falls.

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TABLE OF CONTENTS

LIST OF FIGURES

Text Figures

Appendix Figures

ABSTRACT

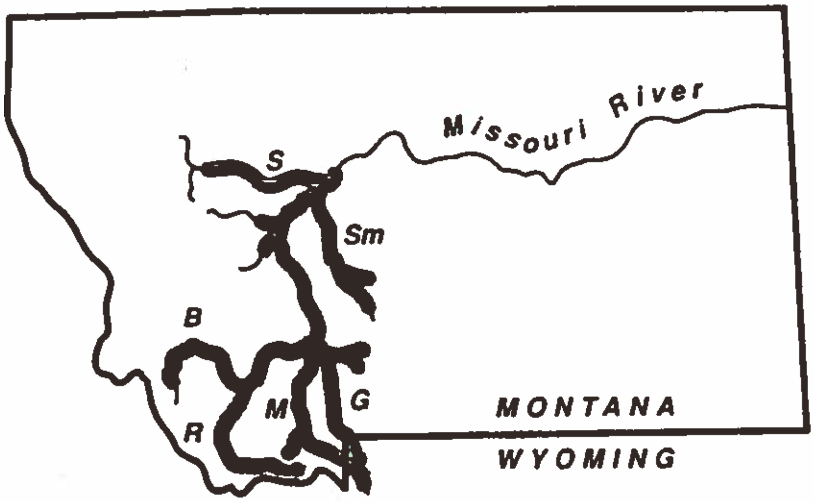
Efforts to restore fluvial Montana Arctic grayling (*Thymallus arcticus*) are necessitated by their severely reduced distribution and numbers. Streams within the native range, the upper Missouri River basin above Great Falls, were evaluated for their potential ability to support self-sustaining populations of grayling. Evaluation criteria were based on a review of characteristics of streams presently and historically occupied or not occupied, apparent effects of non-native salmonids, possible reasons for failure of past plants of graying into streams, effects of access into reservoirs, and presence of a population in an intermittent irrigation canal. Principal criteria included gradient <1%, abundance of pools, absence or scarcity of non-native trout - especially brown trout - presence of a barrier to prevent colonization by non-natives, lack of access to a lake or reservoir, base flow ≥10 cfs, and absence of severe dewatering or other serious habitat degradation. Application of these criteria eliminated most streams within the native range from consideration as potential restoration sites. The primary, indigenous habitat of grayling in Montana - the largest, low gradient streams in broad valleys of the upper Missouri Basin - are no longer suitable habitats for grayling. The factors which probably led to their disappearance from these streams, including establishment of non-native trout, construction of dams and reservoirs, and dewatering of tributaries, remain effective obstacles to restoration of grayling into those waters. Potential restoration sites identified were: the Virginia Meadows section of the upper Gibbon River, Canyon Creek of the Gibbon River drainage, Cougar Creek in the Madison River drainage, the upper Firehole River above Kepler Cascades, a section of Cherry Creek in the Madison River drainage, the upper half of the upper Ruby River above Ruby Reservoir, Elk Creek in the Smith River drainage, the North and South forks of the Sun River above Gibson Reservoir, and the upper Big Hole River above Jackson. None of these stream sections was among the more important indigenous habitats for grayling, and each has limitations which detract from providing the most suitable conditions for supporting a self-sustaining population. The likelihood of successful establishment of grayling may not be high in any of these streams, but efforts are mandated by the severely depressed status of fluvial grayling in Montana.

INTRODUCTION

As specified in the "Request for Proposals" announced by the Montana Chapter of the American Fisheries Society, the purpose of this report is to "identify the reintroduction potential for the Arctic grayling (Thymallus arcticus) into its historic range in Montana", by identifying "potential streams for reintroduction based on life history, habitat requirements, and biological interactions of Arctic grayling with other species." This evaluation of potential sites for reintroduction of grayling into streams is necessitated by the severe decline in distribution of fluvial Montana grayling. This decline of fluvial grayling (defined as those spending their entire lives in riverine habitats) to a single, relatively small, remnant population in the upper Big Hole River, has been summarized by Vincent (1962) and Kaya (1990, 1992). The only other Arctic grayling south of Alaska and Canada disappeared from streams in Michigan during the 1930's. Concern over the remnant status of fluvial Montana grayling is reinforced by studies indicating that Montana grayling are genetically identifiable from those in Alaska and Canada (Lynch and Vyse 1979, Everett and Allendorf 1985), and that fluvial Montana grayling are adapted for existence in a riverine habitat (Shepard and Oswald 1989, Kaya 1991).

The approximately 50 to 80 miles of stream presently occupied by grayling in the upper Big Hole River may represent only about 4 to 5% of the historic distribution of fluvial grayling in Montana (Fig. 1). This is based on my estimate that grayling may have inhabited approximately 2000 km (1250 miles) of stream until about the start of the present century (Kaya 1992). This estimate of historic range assumes, from available evidence (Vincent 1962, Kaya 1990, 1992), that grayling were widely distributed within the native range of the upper Missouri drainage above Great Falls,

A. HISTORIC DISTRIBUTION



B. PRESENT DISTRIBUTION

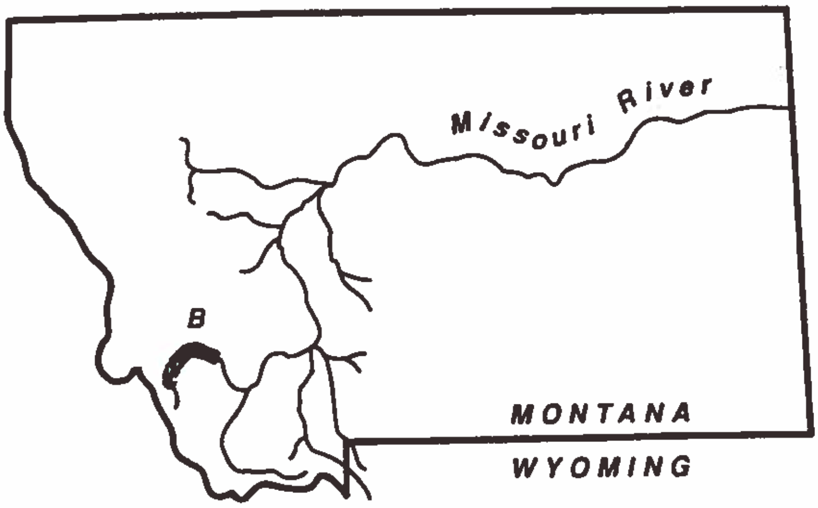


Figure 1. Historic and present distribution of fluvial Arctic grayling in Montana and Wyoming. Major river drainages: S = Sun, Sm = Smith, B = Big Hole, R = Red Rock-Beaverhead-Jefferson, M = Madison, G = Gallatin. Not included on the present distribution are the populations of Madison River/Ennis Reservoir (discussed on page 73) and the Sunny Slope Canal (discussed on page 14).

and occupied the main stem of the Missouri River, the main stems of its major branches, and the lower reaches of other, larger tributaries.

Fluvial Montana grayling are categorized as a fish of "Special Concern" by the Endangered Species Committee of the American Fisheries Society (Williams et al. 1989), by the Fishes of Special Concern Committee of the Montana Chapter of the American Fisheries Society, by the Montana Department of Fish, Wildlife and Parks (MDFWP), and by the Montana Natural Heritage Program (Genter 1992). The U.S. Fish and Wildlife Service classifies fluvial Montana grayling in Category 1, the final category before listing as threatened or endangered, and was petitioned, in October 1991, to list these fish as endangered. An interagency, Fluvial Arctic Grayling Workgroup was formed in 1988 with representatives from state, federal, and private agencies and developed a "Restoration Plan" in 1990 to conserve, enhance, and restore fluvial Montana grayling. The plan recommends measures to conserve and enhance the remnant population of the Big Hole River, and also recommends taking steps to restore fluvial grayling to other streams within the native range, by first identifying drainages that could support self-sustaining populations.

Before streams can be identified as being capable of sustaining self-sustaining populations of fluvial Montana grayling, two important categories of factors need to be recognized. One would be the habitat characteristics which enable grayling to persist and reproduce in a stream. The second would be those factors which contributed to the disappearance of fluvial grayling from most streams they once occupied and which, if still present or operative, would likely prevent their restoration to a stream. For streams known to be formerly occupied by grayling, a most important question would be whether conditions have changed since the native population was eliminated, so that prospects have improved for restoration of grayling to the same stream. If the answer is negative, and if it is not feasible to effect changes to improve conditions for grayling, then such a stream would not not be a good candidate for restoration of a fluvial population. The same factors which led to the decline and disappearance of the native population would likely act to prevent restoration of a self-sustaining population to the stream.

Habitat requirements for fluvial Arctic grayling can be evaluated by considering information from different perspectives. One perspective is provided by the characteristics of streams presently and previously occupied by fluvial grayling in Montana, and to a lesser extent in Alaska and Canada. Other, previous evaluations of habitat requirements for Arctic grayling (Hubert et al. 1985, Reynolds et al. 1989) have relied heavily on characteristics of occupied streams. Another perspective is provided by the characteristics of streams known not to be occupied historically, when grayling were widely distributed, and also by characteristics of streams in which grayling were planted but failed to become established. The following section discusses such information, on which the criteria defining suitable habitat are based.

More difficult to evaluate are factors which may have contributed to the decline and disappearance of grayling from most streams in the native range in Montana. The possible factors are discussed by Vincent (1962) and Kaya (1990, 1992). The most important are believed to be: (1) negative interactions with non-native brown, rainbow and brook trout; (2) habitat alterations including seasonal dewatering, diversion of water and fish into irrigation ditches, and construction of dams and reservoirs on previously unimpeded rivers; and (3) fishing overharvest. Of these three categories of negative effects, fishing overharvest is not a habitat parameter and can be readily controlled, via angling regulations. In the following section, I discuss the role of the other two categories of factors, non-native trout and habitat alterations, on establishment of criteria for identification of candidate streams.

FACTORS CONSIDERED IN ESTABLISHING CRITERIA FOR EVALUATING STREAMS

A. Physical Characteristics of Past and Present Fluvial Grayling Habitat

The known historic distribution of grayling in Montana, dating from the time of the Lewis and Clark Expedition of 1805-1806, suggests that they were characteristically fluvial fish that occupied larger, low gradient streams of the Missouri River drainage upstream from the Great Falls of the Missouri. In his comprehensive review, Vincent (1962) compiled a large amount of information from various sources, including published and unpublished reports and "old-timer" personal accounts, and derived the following historic, native pattern of distribution of grayling in Montana and Wyoming. (1) Grayling were widely but irregularly distributed in the upper Missouri River drainage upstream from Great Falls, and were most common in low gradient reaches of the larger streams: the Missouri River between Great Falls and its origin at Three Forks, the Gallatin River and its major tributary the East Gallatin River, the Madison River and its two branches the Firehole and Gibbon Rivers up to the first barrier falls, the Jefferson River and its branches the Big Hole River and the Beaverhead (and its tributary the Red Rock River), the Smith River up to near the present town of White Sulphur Springs, and the Sun River up to the first barrier falls below the present Gibson Reservoir. (2) Grayling also were present in some smaller tributaries that were not isolated from these larger streams by barriers, particularly in low gradient reaches close to their mouths. Examples were sections of Sheep Creek, tributary to the Smith River; Bozeman and Bridger creeks, tributaries of the East Gallatin River; Horsethief Spring Creek, former tributary (now submerged beneath Hebgen Reservoir) to the Madison River; and various tributaries of the Big Hole River. Recent observations on distribution and movements of grayling in the Big Hole drainage suggests that fish in the lower reaches of such tributaries are part of the population inhabiting the larger main stream (Shepard and Oswald 1989, Byorth 1991). They appeared not to have inhabited steeper gradient, upper reaches of tributaries, even when these upper reaches were not isolated by barrier falls (Nelson 1954). (3) They were not present above barriers to upstream movement and were thus absent from mountainous reaches of all tributaries, and from nearly all lakes. The only lakes known to have had native populations of Montana grayling were Upper and Lower Red Rock lakes and possibly nearby Elk Lake. These lacustrine grayling temporarily entered streams to spawn.

On the basis of this pattern of historic distribution, Vincent (1962) concluded that grayling in Montana occupied habitats with low gradients of up to 20 ft per mile (about 0.4 %), water velocities of 1 to 2 ft/s, water depths of 1 to 3 ft, with spawning substrate of coarse sand to fine gravel, and with beds of macrophyte vegetation being common. More recently, Liknes (1981) found the greatest number of grayling on the Big Hole River in a section near Wisdom, that had a gradient of 0.3 % and mean velocity of 0.7 ft/s. Adult grayling in Alaska have been reported to spend most of their time in similar current velocities of 0.8 ft/s (Kreuger 1981, cited by Hubert et al. 1985).

Lower water velocities may be required for underyearling juveniles. McClure and Gould (1991) reported that 2.4 to 2.7 inch grayling were located with greatest frequency in the slowest velocities available, ≤0.06 to ≤0.13 ft/s (≤2 to ≤4 cm/s), in enclosures within an artificial stream. However, McMichael (1990) reported that young-of-year grayling in the Big Hole River, ranging from about 2.5 to 4.0 inches in length, were captured with greatest frequency at velocities of 0.12-0.24 ft/s, and appeared to inhabit even faster velocities in greater proportion than available.

Stream areas with low current velocity appear especially important to young grayling fry from swimup to several weeks of age. Nelson (1954) reported that lacustrine grayling fry in Red Rock Creek spend the first two to three weeks post-swimup in backwaters and other areas protected from fast currents. Deleray (1990) observed that grayling fry less than three weeks post-swimup appeared to prefer velocities of ≤0.16 ft/s (5 cm/s). Hubert et al. (1985) and Reynolds (1989) concluded that optimum habitat for fluvial grayling fry are stream reaches with at least 30% of total area made up of pools, backwaters, and side channels with mean column velocity less than 15 cm/s (0.49 ft/s).

More recent observations have indicated that another important component of fluvial grayling habitat is the presence of pools. Pools provide deep, low-velocity habitat preferred by fluvial grayling. Electrofishing surveys have indicated that fluvial grayling in Montana and Alaska spend most time in pools rather than riffles (Hubert et al. 1985, Reynolds 1989, Shepard and Oswald 1989). Among three sections of the Big Hole River sampled in one study (Liknes 1981, Liknes and Gould 1986), grayling were most common in the section with the highest pool:riffle ratio and lowest pool-riffle periodicity (the mean distance between pools and between riffles, measured in mean stream widths). Liknes (1981) defined pools in the Big Hole River as areas with maximum depths ≥0.5 m (1.64 ft), slow water velocities, and smooth water surfaces. Grayling that formerly occupied the Madison River also were concentrated in pools; Fuqua (1929) described grayling as abundant in the deep holes of the river between Ennis Reservoir and Hebgen Dam. Pools also provide critical winter habitat for fluvial grayling in Montana and Alaska. In Alaskan rivers, grayling overwinter in large, deep pools with depth greater than 1.2 m (3.9 ft) and current velocities of less than 15 cm/s (0.5 ft/s), or in springfed reaches of small streams that do not freeze solid in winter (Reynolds 1989). Grayling in the Big Hole River appear to have similar requirements for winter habitat (Shepard and Oswald 1989).

Fluvial grayling in the Big Hole River and in Alaska undergo extensive upstream and downstream migrations. While migratory patterns differ among streams and even within streams, a common pattern is movement upstream to spawning and summering areas and downstream to wintering areas with large volumes and large, deep pools (Reynolds 1989, Shepard and Oswald 1989). Big Hole River grayling have been observed to migrate as far as about 50 miles. However, some grayling in this river appear to remain in the upper reaches and overwinter in stretches or tributaries with upwelling spring water (Shepard and Oswald 1989). It is not known whether grayling in other Montana streams were also migratory, especially those reported to have been present in smaller waters like Sheep Creek in the Smith River drainage, Bozeman Creek in the East Gallatin River drainage, or Horsethief Spring Creek in the Madison River drainage. Vincent (1962) states that grayling in Michigan apparently were non-migratory.

B. Access to Lakes or Reservoirs

Access to reservoirs or natural lakes may not be compatible with persistence of a completely fluvial grayling population. With the possible exception of the Madison River above Ennis Reservoir, grayling have disappeared from or failed to establish fluvial populations in all streams in which fish can freely move both into and out of a reservoir or lake. Unimpeded access to reservoirs was probably not the only factor contributing to disappearance of grayling from such streams. Other factors, such as introduction of non-native salmonids, also were associated with the disappearance of grayling from streams associated with reservoirs, and grayling disappeared from the Gallatin, Jefferson and Smith Rivers which do not have reservoirs on their main stems. Also, access to a reservoir was apparently not involved in disappearance of grayling from stream sections below dams, such as the Missouri River below Holter Reservoir, the Sun River below Gibson Reservoir, the Beaverhead River below Clark Canyon Reservoir, and the Madison River below Ennis Reservoir.

Despite the preceding exceptions, the historic pattern of relationship between reservoirs and fluvial grayling in Montana suggests a negative effect of unimpeded access to reservoirs. Fluvial grayling persist in the Big Hole River which does not have a reservoir on it, but have disappeared from the Missouri River above Canyon Ferry Reservoir, and Red Rock River above both Lima and Clark Canyon reservoirs. On the Madison River, grayling disappeared above Hebgen Reservoir from both the Madison River and the South Fork of the Madison River. Grayling with partially fluvial characteristics persist in Ennis Reservoir and are present upstream from the reservoir during summer and fall (Byorth and Shepard 1990). It appears, however, that most of these Madison/Ennis grayling spend much of their lives in the reservoir. A hypothesis advanced by Dick Vincent and Pat Byorth (pers. comm.) is that construction of a reservoir on a stream creates a giant pool habitat which is used by a progressively greater proportion of the river's grayling, until virtually the entire population is occupying the reservoir during much of the non-spawning season. It appears also that extended duration of stream residence by Madison/Ennis grayling is related to the relatively large size of this stream. In all the other, much smaller tributaries of lakes and reservoirs in Montana with grayling populations, adults only briefly enter streams to spawn during spring or early summer (e.g., Brown 1938, Peterman 1972, Lund 1974, Wells 1976, Nelson 1954). Fluvial populations have not become established in any tributaries of the numerous lakes in which grayling have been planted.

C. Effects of Non-Native Salmonids

The introduction of non-native fishes, especially salmonids, has likely been an important, and perhaps the most critical, factor affecting the decline of fluvial grayling in Montana. Fluvial grayling in Montana were originally sympatric with only ten other species of fish, including two or three native salmonids, westslope cutthroat trout (Oncorhynchus clarki lewisi) and mountain whitefish (Prosopium williamsoni), and possibly lake trout (Salvelinus namaycush) in Elk Lake of the Red Rock River drainage. Observations by Lee (1985) suggest that grayling in Alaska can compete effectively with native fluvial salmonids.

All streams in Montana known to have been formerly occupied by grayling now contain one or more introduced salmonids (Vincent 1962, Kaya 1990) - brook trout (Salvelinus fontinalis), brown trout Salmo trutta), or rainbow trout (Oncorhynchus mykiss). Establishment of these same species also were an important factor contributing to the decline and extirpation of grayling from streams in Michigan (Vincent 1962). Brook trout appeared to be the most important competitor in Michigan, although rainbow trout also may have been important in the Au Sable River. In Montana, all three species became established at about the same time, in the late 1800's. Decline of grayling in the Madison River was associated with establishment of both brown and rainbow trout populations. At present, fluvial grayling in the upper Big Hole River coexist with brook trout, which have been in the river since about 1929 (Liknes 1981), and small numbers of rainbow and brown trout. In the Big Hole River, grayling are scarce both below the Divide Dam, where brown and rainbow trout are abundant, and in upper reaches above the town of Jackson, where brook trout are abundant.

Interactions with non-native salmonids could include competition and predation. Competition occurs through common use of limited resources including food, shelter, and spawning habitat, and can lead to decline or elimination of less successful competitors. Skaar (1989) found differences in habitat occupied by brook trout and grayling in the upper Big Hole River. Age-1+ brook trout were most abundant in higher gradient sections and faster flowing water, while grayling were more typically found in slow runs or pools with depths of 0.6 m or greater. It is not known whether this difference in habitat occupied results from difference in preferences, or from competitive displacement of one by the other.

Grayling may be highly susceptible to predation in early stages of development. Eggs are broadcast over the substrate instead of being buried, and young grayling fry are smaller and are weaker swimmers than trout fry. Newly swimming grayling fry are about 9 to 11 mm in length (Kaya 1991), compared to 20 to 26 mm for rainbow, brown, and brook trout fry (Northcote 1962, Heggenes and Traaen 1988). Nelson (1954) found grayling fry in the stomachs of brook trout in Red Rock Creek, a spawning tributary of Upper Red Rock Lake. McMichael (1990) and Streu (1990) found little or no evidence of predation on young grayling in the Big Hole River by brook trout or other fishes. However, stomach samples for these studies were collected from potential predators during summer, and not during the late spring when the fry are newly swimming and likely to be most susceptible to predation.

D. Failure of Prior Plants of Grayling into Streams

Millions of grayling have been planted into streams in Montana and elsewhere, without producing a single self-sustaining population in any stream (reviewed by Kaya 1990). Several factors probably contributed to these failures. Almost all grayling stocked into streams were taken from lacustrine populations, which may not have the behavioral adaptations important for existence as stream fish (Jones et al. 1977, Kaya 1991). Most grayling planted were very young, yolksac or only recently free-swimming fry (Kelly 1931) that appeared to have very low survival in streams. These first two problems are now resolved, since fluvial grayling have been successfully reared in large numbers and to sizes up to adulthood at the Fish Technology Center, U.S. Fish and Wildlife Service, in Bozeman. Probably more important, with respect to formulating criteria for potential grayling streams, is that most streams stocked were small, or had moderate to high gradients, or were populated by established populations of non-native trout.

Two recent efforts have been made to stock streams with grayling of fluvial origin, and planted as fish much larger than fry. In August 1976, 120 grayling of various sizes captured from the Big Hole River were released into Canyon Creek, a tributary of the Gibbon River in Yellowstone National Park. Other grayling, from lacustrine sources, were also planted into Canyon Creek in 1976, 1977, 1978, and 1980 (Jones et al. 1981). The creek had been treated to remove non-native brown, rainbow and brook trout and a barrier built to prevent their recolonization from the Gibbon River. Electrofishing surveys revealed many non-native brown, rainbow and brook trout and only few grayling in 1978 and no grayling in September 1980. At least three factors may have contributed to the failure of these efforts in Canyon Creek: small size (estimated discharge of about 4 to 7.5 cfs), gradient about 1%, and incomplete removal of or rapid recolonization by brown, rainbow, and brook trout.

In 1983, two transplants were made of grayling captured from Sunny Slope Canal (Bill Hill, pers. comm.). This canal population is described in a following section of this report. In their canal habitat, these fish need to maintain their position in flowing water for about five months of the year. In April, about 600 were transplanted into the Sun River below Diversion Dam (downstream from Gibson Reservoir). In October about 400 were transplanted into Rock Creek, a tributary of the North Fork of the Sun River, above Gibson Reservoir. These were mostly age-0 fish about 5 to 6 inches in length. Neither attempt resulted in the establishment of fluvial populations. Both brown and rainbow trout are present in the Sun River, and rainbow, brook, and cutthroat trout are present in the North Fork. Rock Creek did appear to present favorable habitat with its low gradient, discharge of about 25 cfs, absence of other fish, and location above a natural barrier. However, the planted fish appeared to drift down out of Rock Creek, into the North Fork, and at least as far as the confluence of the North and South Forks at the reservoir.

The most recent plant of fluvial fish occurred very recently, when 5,400 yearling grayling, 4 to 8 inches in length, were released into the upper Gallatin River in July 1992. Catches by fishermen indicate that these fish traveled over the next two to three months from the planting site near the Yellowstone Park boundary to the lower reaches near the confluence with the East Gallatin River and even into the latter tributary (Vincent, pers. comm.) Some fish caught by fishermen had traveled as far as 65 miles downstream (Byorth 1992). The distribution and fate of these fish will continue to be monitored by the Montana Department of Fish, Wildlife and Parks. The redistribution of these Big Hole River fish in the Gallatin River suggests that they will not remain in unsuitable habitat. In the case of the Gallatin River, the upper river may have too steep gradient and too few large, deep pools. As of October, 1992, three months after the planting date, they seemed to have moved to the lower section of the river with low gradient and large pools. Since this part of the river also supports sizeable populations of brown and rainbow trout, the eventual outcome of this introduction will be of much interest and relevance to future introductions into other streams.

E. Sunny Slope Canal

The presence of a grayling population in this unusual habitat, an irrigation canal with intermittent flow, presents interesting questions about grayling habitat requirements. The following information about the Sunny Slope Canal and its population of grayling is based on interviews with Bill Hill, MDFWP, who has observed these grayling for about 20 years. For about five months of the year, May through September, the canal transports roughly 1700 çfs released from Pishkun Reservoir. But for about seven months, from October through April, the outlet gate is closed at the reservoir and flow ceases in the canal. During this latter period, habitat for grayling is reduced to isolated pools. Pat Byorth and I visited the site in October 1992, in the company of Bill Hill, and observed grayling in these isolated habitats.

Grayling were planted in Pishkun Reservoir at least seven times from 1937 to 1942 (MDFWP Fish Planting Database), and have been known to be present in the canal since at least 1971. Grayling had virtually disappeared from the reservoir by that time (Hill, pers. comm.), and there have been no confirmed captures from the reservoir since. The grayling in the canal therefore appear to represent a self-sustaining population. During the seven months without water flow through the canal, grayling are present in isolated pools from the reservoir outlet to at least 40 miles downstream, near the town of Fairfield. The canal is subdivided along this length by four inclined, concrete drop structures which prevent any upstream movement of fish. Therefore, unless there is an undetected remnant population in the reservoir, the grayling above the uppermost drop structure must be sustained by local reproduction and recruitment. Those in other sections further downstream also could be reproducing, but it is also possible that their presence is being maintained by drift of fish from upstream reaches. Few other fish are present in the canal, including a few rainbow trout, northern pike, and suckers. Population sizes are not known but probably total at least in the hundreds for grayling. About 1,000 were captured from pools in April and October, 1983, for transfer to the Sun River and a tributary (Hill pers. comm., and MDFWP fish planting database).

The presence of these fish in such an unusual situation presents interesting questions about suitable habitat for fluvial grayling. This suggests that grayling can exist and maintain a population in otherwise poor habitat, if other requirements are satisfied such as availability of pools for overwintering, low gradient, and absence or scarcity of competing fishes (or if grayling are better able to tolerate poor habitat conditions than potential competitors). The canal's habitat quality is substantially reduced by severe dewatering, and possibly by low dissolved oygen levels beneath ice cover in the isolated pools (winter habitat conditions have not yet been investigated). Perhaps it is significant that, unlike natural streams dewatered for irrigation during summer, flow is not seriously reduced in the canal until fall. Thus, flow is maximum during the period when age-0 fish are produced, and during the spring through late summer feeding and growing season for fish of all ages, and possibly also during the spawning period (times of spawning not known for these canal grayling). Cessation of flow in October then confines the grayling in the isolated pools until the following May. Also of possible importance are the lack of access back into the reservoir, and the removal from the upstream gene pool of any fish that passed down any drop structure. These may have acted as strong selective factors favoring those individuals that could survive without access to a lacustrine environment, and that had a behavioral tendency to maintain position within limited reaches.

CRITERIA FOR EVALUATING STREAMS

The following assumptions and criteria were based on the preceding review of habitats historically and presently occupied by fluvial grayling in Montana (and to a lesser extent in Alaska and Michigan), apparent negative effects of unimpeded access to lakes or reservoirs, negative effects of establishment of non-native salmonids, and failures of past plants of grayling into streams. Several assumptions have been made in formulating these criteria: (1) It is assumed that the habitats formerly or presently occupied by fluvial grayling provide important indices to habitat suitability for these fish. (2) It is assumed that although fluvial grayling have been found most commonly in relatively large rivers in Montana, Michigan, and Alaska, they can also exist in smaller streams if other habitat conditions are appropriate (such as low gradient, pools, lack of non-native salmonids). This assumption is based on the reported former presence of grayling in such streams as Bozeman and Bridger creeks, tributaries of the East Gallatin River (Evermann 1893), in which discharge gets at least as low as 10 cfs (personal observations), and on the presence through winter of grayling in isolated pools in Sunny Slope Canal. (3) It is assumed that fluvial grayling cannot coexist in a stream with well-established, thriving populations of non-native trout, especially brown trout. (4) It is assumed that a fluvial grayling population does not require long distances of unobstructed stream for migrations, if suitable summer habitat for spawning and feeding and overwintering habitat in pools or in areas with spring discharges are available within more limited sections. (5) It is assumed that grayling will not remain fluvial, especially in a small stream, if they have unimpeded access to a nearby lake or reservoir.

A stream or section of stream within the historic range of the upper Missouri drainage above Great Falls was considered to have the highest suitability for attempts to restore or newly establish a self-sustaining population of fluvial grayling if it satisfied the following criteria.

1. Gradient should be less than 1%. Water velocities should be slow to moderate, at 1 to 2 ft/s or less. Low velocity is associated with low gradient and is not treated as a separate criterion.

2. Pools, preferably with depths of $\geq$1.6 ft, or areas of major upwellings of spring water should be abundant. Pools or spring upwellings also are especially important as winter habitat.

3. Non-native trout, especially brown trout, should not be present, or present at only low densities, or the stream appears treatable for removal or reduction of non-natives. Whether a stream is treatable would be related to socio-political as well as physical considerations.

4. Colonization or recolonization of the stream by non-native salmonids from adjacent waters can be prevented or inhibited, either because a barrier exists or because construction of a barrier is feasible.

5. Unless large (e.g. minimum flow > 200-300 cfs), the stream should not be a direct tributary of a nearby lake or reservoir.

6. The stream should be generally capable of supporting a self-sustaining population of grayling, with minimum low flows not less than about 10 cfs, summer temperatures not exceeding 74 F (23.3 C), presence of riffles with gravel substrate for spawning, and no serious stream pollution or degradation. Other desireable characteristics would include: high biological productivity, including abundance of rooted macrophyte vegetation; and abundance of backwaters and other areas of slow velocity for fry habitat.

These criteria were applied to streams in the native range of fluvial grayling, the Missouri River drainage above Great Falls. The upper Big Hole River and tributaries between Wisdom and Divide were not included, since these waters presently contain the remnant population of fluvial Montana grayling. Similarly, the Madison River and tributaries between Ennis and Hebgen reservoirs were not included, since a portion of these waters are inhabited by Ennis Reservoir/Madison River grayling which may have partially fluvial characterstics. This population is being studied intensively at present by biologists from MDFWP and Montana Power Company. If this Madison River/Ennis Reservoir population becomes more numerous or extends its range upstream, a greater portion of this part of the native range will become occupied.

Evaluation consisted of the following sequence. Streams with flows of less than 10 cfs were considered too small to support self-sustaining fluvial populations of grayling and were generally not considered further and do not appear in this report. Next, lists were made of those streams with serious deficiencies in each of the following four categories: (1) average gradient exceeding 1%; (2) non-native trout, especially brown trout, present; (3) unimpeded, bidirectional access for fish to a reservoir or lake; and (4) severe dewatering or other degradation of water quality. These four criteria were not only among the most important, but also could be evaluated for most streams through information available from printed sources, computer databases, or U.S. Geological Survey maps. Streams that appeared on these lists were considered to be seriously deficient in fulfilling habitat criteria and were generally not considered further. With exceptions described for those that were evaluated further, the criteria were applied to streams in their present condition, without considering whether serious deficiencies could be remedied. It is possible that some of the streams in this first category could be rehabilitated to make them more suitable as grayling habitat. However, evaluation of possible mitigation measures within each stream of the upper Missouri River drainage was considered to be beyond the intended scope of this report.

Streams that appeared to satisfy these first four criteria or that appeared to marginally violate only one or two criteria were subject to additional evaluation. These relatively few remaining streams were further evaluated, through a combination of published and unpublished information available, discussions with fishery biologists in the respective regions, and on-site examinations of the streams. The streams of the Missouri drainage above Great Falls, generally with flows greater than 10 cfs, are thus presented in three categories with reasons for inclusion in each category stated: first, those streams that appeared to be seriously deficient in meeting habitat criteria and were eliminated from further consideration; second, streams that were evaluated further but appear to be unsuitable; and third, those streams that appear to have some potential as sites for attempts to establish self-sustaining populations of fluvial grayling. Maps of the drainages and streams discussed are in Appendix III.

EVALUATION OF STREAMS

A. Streams with Apparently Serious Habitat Deficiencies, and Not Evaluated Further

(Information sources were primarily MDFWP 1981, 1989a, 1989b, Montana Interagency Stream Fishery Data (computer database), Parrett et al. 1989, and U. S. Geological Survey area maps, 1:24,000 scale. Maps of drainages and streams are in Appendix III.)

* = streams seriously deficient in more than one criterion

[1] = streams with historic evidence as indigenous grayling habitat

GRADIENT EXCEEDS 1% (>10 ft/1,000 ft)

Red Rock-Beaverhead River Drainage

Jones Creek, of Lower RR Lake (45 ft)
Peet Creek, of upper RR River (42 ft)
East Fk Clover Creek, of Upper RR River (72 ft)
Indian Creek, of Big Sheep Creek (33 ft)
Cabin Creek, of Big Sheep Creek (22 ft)
Simpson Creek, of Big Sheep Creek (49 ft)
*Deadman Creek, of Big Sheep Creek (28 ft)
Black Canyon Creek, of Horse Prairie Creek (45 ft)
Shenon Creek, of Horse Prairie Creek (66 ft)
Trapper Creek, of Horse Prairie Creek (74 ft)
Bear Creek, of Horse Prairie Creek (49 ft)
*Rape Creek, of Horse Prairie Creek (70 ft)
N. Fork of Greenhorn Creek (82 ft)

Ruby River Drainage

*Cottonwood Creek (56 ft)

Jefferson River
*South Boulder River (28 ft)
*North Willow Creek (60 ft)

Madison River

*Watkins Creek above Hebgen Reservoir (84 ft)
*Cabin Creek (45 ft)

Gallatin-East Gallatin

*West Fork of the Gallatin (23 ft, higher in Middle and S. Forks)
*Squaw Creek (50 ft)
*Hell Roaring Creek (66 ft)
Big Bear Creek (54 ft)
*South Cottonwood Creek (40 ft)
*Spanish Creek (13 ft)
*East Fork of Hyalite Creek, reservoir to 4 miles above (33)
*South Fork of Hyalite Creek, reservoir to 5 miles above (28)
*Hyalite Creek, reservoir to canyon mouth (24)

Missouri between Canyon Ferry Reservoir and Great Falls

*Trout Creek, Hauser Reservoir to 6 miles above (12)

Sun River

*North Fork Willow Creek (29)

BROWN OR RAINBOW TROUT ESTABLISHED

(Abbreviations of trout present, both native and non-native:
EB = brook trout, BR = brown trout, RB = rainbow trout,
CT = cutthroat trout, KOK = kokanee salmon)

Red Rock - Beaverhead River

[1]*Lower RR River, between Lima and Clark Canyon reservoirs (BR, RB)
*Deadman Creek, of Big Sheep Creek (RB, and CT)
Big Sheep Creek, of Red Rock River (RB, BR)
Bloody Dick Creek, of Horse Prairie Creek (RB, and EB)
*Medicine Lodge Creek, of Horse Prairie Creek (RB, and EB)
*Horse Prairie Creek, of Clark Canyon Reservoir (RB, BR, and EB)
[1]Beaverhead River (BR, RB)
*Grasshopper Creek, of Beaverhead (BR, RB, and EB)
Poindexter Slough, of Beaverhead (BR, RB, and EB)
*Blacktail Deer Creek, of Beaverhead (RB)

Ruby River

*Ruby River upstream from reservoir, including Middle, East, and West Forks (RB, BR, and CT)
*Ruby River downstream from reservoir (BR, RB)
*Cottonwood Creek (RB, and CT)
*Warm Springs Creek (RB, and CT)
*Mill Creek (EB, and CT)
*Wisconsin Creek (RB, and EB)

Jefferson River

[1]Jefferson River, to mouth at Three Forks (BR, RB)
Hells Canyon Creek (RB, BR, and EB)
Willow Spring Creek (BR, RB, EB)
*Whitetail Creek (RB, BR)
Boulder River (RB, BR, and EB)
*South Boulder River (RB, BR, and EB)
*South Willow Creek (RB, BR, and EB)
*North Willow Creek (RB, BR, and EB)
Willow Creek (BR, RB, and EB)

Madison

[1]*Madison above Quake Lake and Hebgen Reservoir (BR, RB, and EB)
[1]*Madison below Ennis Reservoir (BR, RB)
[1]Gibbon River (BR, RB, EB)
Firehole River between Kepler Cascades and Madison River (BR, RB)
[1]*South Fork of Madison above Hebgen Reservoir (BR, RB, and EB)
*Red Canyon Creek, above Hebgen Reservoir (RB, and CT)
*Watkins Creek, above Hebgen Reservoir (RB, and CT)
*Trapper Creek, above Hebgen Reservoir (RB, and CT)
*Cabin Creek (RB, BR, and CT)
[1]*Beaver Creek (RB, BR, and CT)
*Antelope Creek, of Cliff Lake (RB)
Hot Springs Creek (RB, BR, and EB)
Cherry Creek (RB, BR, and EB)
Darlington Ditch (BR, RB)

Gallatin-East Gallatin

[1]Gallatin River, from YNP to mouth at Three Forks (RB, BR, EB, and CT)
*Taylor Fork (RB, BR, and CT)
Porcupine Creek (RB, BR, and CT)
*West Fork of the Gallatin, and its Middle and S. Forks (RB, BR, and CT)
*Squaw Creek (RB, BR, and EB)
*Hell Roaring (RB)
*Spanish Creek (RB, and EB)
*South Cottonwood Creek (RB, BR, and EB)
Baker Creek (BR, RB)
Rocky Creek (RB, BR, and EB)
[1]Sourdough Creek (RB, BR, and EB)
[1]Bridger Creek (RB, BR, EB)
*Hyalite Creek, below Hyalite Reservoir (RB, EB, and CT)
Reese Creek (BR, RB, and EB)
Thompson Spring Creek (RB, BR, and EB)
Ben Hart Spring Creek (RB, BR, and EB)
[1]*East Gallatin River (RB, BR, EB, and CT)
*Rey Creek (BR, RB)

Missouri River above Canyon Ferry Reservoir

[1]Missouri River above Canyon Ferry Reservoir (RB, BR)
Sixteen Mile Creek (RB, BR, EB, and CT)
*Crow Creek (RB, and EB)
Dry Creek (RB, and EB)
*Deep Creek (RB, BR, and EB)
*Duck Creek, of Canyon Ferry Reservoir (RB, and EB)
*Confederate Gulch, of Canyon Ferry Reservoir (RB, BR, and EB)
*Beaver Creek, of Canyon Ferry Reservoir (RB, and EB)
*Avalanche Creek, of Canyon Ferry Reservoir (RB)

Missouri River between Canyon Ferry Reservoir and Great Falls

[1]*Missouri River between Hauser Dam and Holter Reservoir (RB, BR, KOK, and also walleye)
[1]*Missouri River between Holter Dam and Great Falls (RB, BR, and also walleye and burbot)
*Spokane Creek, of Hauser Reservoir (BR, RB, and KOK)
*McGuire Creek, of Hauser Reservoir (BR, RB, and KOK)
*Trout Creek, of Hauser Reservoir (BR, RB, KOK)
*Prickley Pear Creek and tributaries (BR, RB, and KOK)
*Silver Creek, of Lake Helena (BR, RB, EB and KOK)
*Beaver Creek, trib. to Missouri above Holter Reservoir (RB, BR, EB, and CT)
*Willow Creek, of Holter Reservoir (RB, EB, and CT)
*Cottonwood Creek, of Holter Reservoir (RB, BR, and EB)
Little Prickly Pear Creek (RB, BR, and EB)
Virginia Creek, trib. to Little Prickly Pear Creek (RB, and EB)
Canyon Creek, trib. to Little Prickly Pear Creek (RB, BR, and EB)
Lyons Creek, trib. to Little Prickly Pear Creek (RB, BR, and EB)
Wolf Creek, trib. to Little Prickly Pear Creek (RB, BR, and EB)
*Wegner Creek (RB)
Stickney Creek (RB, and EB)
Dearborn River (RB, BR, and EB)
Middle and South Forks, Dearborn River (RB, and EB)
*Flat Creek, trib. of Dearborn River (RB, BR)
Sheep Creek (RB, BR, and EB)

Smith River

[1]Smith River, from confluence of N. and S. Forks to mouth (RB, BR, EB, and CT)
[1]*North Fork Smith River (BR, RB, and EB)
[1]Sheep Creek (RB, BR, EB, and CT)
Eagle Creek (RB, EB, and CT)
Rock Creek (RB, BR, EB, and CT)
*Tenderfoot Creek (RB, and CT)
Hound Creek (RB, BR, and EB)

Sun River

[1]Sun River from Diversion Dam to mouth at Missouri (RB, BR)
*Willow Creek (a few RB)
Elk Creek (RB, BR, and EB)

ACCESS TO NEARBY LAKE OR RESERVOIR

Red Rock - Beaverhead River

[1]*Lower Red Rock River, between Lima and Clark Canyon reservoirs
Red Rock, Hell Roaring, Corral, creeks above Upper Red Rock Lake
Elk Spring Creek above Upper Red Rock Lake
Tom Creek, of Upper Red Rock Lake
*Horse Prairie Creek, of Clark Canyon Reservoir
*Rape Creek above storage reservoir

Ruby

*Ruby River upstream from Ruby Reservoir

Jefferson

*South Willow Creek, of Harrison Reservoir

Madison

[1]*Madison River above Quake Lake and Hebgen Reservoir
[1]*South Fork of Madison, of Hebgen Reservoir
*Red Canyon Creek, of Hebgen Reservoir
*Watkins Creek, of Hebgen Reservoir
[1]*Beaver Creek, of Quake Lake
*Antelope Creek, of Cliff Lake

Gallatin-East Gallatin

*East and South Forks of Hyalite, of Hyalite Reservoir

Missouri above Canyon Ferry Reservoir

*Missouri River above Canyon Ferry Reservoir
*Deep Creek, on Missouri near Canyon Ferry Reservoir
*Duck Creek, of Canyon Ferry Reservoir
*Confederate Gulch, of Canyon Ferry Reservoir
*Beaver Creek, of Canyon Ferry Reservoir

*Avalanche Creek, of Canyon Ferry Reservoir

Missouri River between Canyon Ferry Reservoir and Great Falls

*Missouri River between Hauser Dam and Holter Reservoir
*Spokane Creek, of Hauser Reservoir
*McGuire Creek, of Hauser Reservoir
*Trout Creek, of Hauser Reservoir
*Prickly Pear Creek and tributaries, of Lake Helena
*Silver Creek, of Lake Helena
*Beaver Creek, trib. to Missouri above Holter Reservoir
*Willow Creek, of Holter Reservoir
*Cottonwood Creek, of Holter Reservoir

Smith River

*North Fork Smith Creek above Reservoir

Sun River

*North Fork above Gibson Reservoir
*Willow Creek above reservoir

EXCESSIVE DEGRADATION

(listing in this category derived mostly from descriptions of stream degradation in MDFWP 1989a, 1989b)

Red Rock - Beaverhead

Long Creek, of Upper Red Rock River (lower three miles dewatered)
*Medicine Lodge Creek, of Horse Prairie Creek (summer dewatering)
*Horse Prairie Creek, of Clark Canyon Reservoir (summer dewatering)
*Grasshopper Creek, of Beaverhead (toxic metals, dewatering)
*Blacktail Deer Creek, of Beaverhead (summer dewatering)

Ruby River

*Ruby River below reservoir (summer dewatering)
*Warm Springs Creek (warm temperatures from thermal springs)
*Mill Creek (summer dewatering)
*Wisconsin Creek (summer dewatering)

Jefferson River

*Whitetail Creek (dewatering of lower reaches)

*Boulder River below Basin (toxic metals)
*South Willow Creek (partial dewatering of lower half)

Madison River

[1]*Beaver Creek (high sediment input)

Gallatin-East Gallatin

*Taylor Fork (high sediment input)
*Hyalite Creek (lower, lesser gradient reaches completely dewatered)
*Thompson Spring Creek (siltation)
*Rey Creek (siltation, turbidity)

Missouri above Canyon Ferry Reservoir

*Crow Creek (lower reaches severely dewatered)

Missouri between Canyon Ferry Reservoir and Great Falls

*Prickley Pear Creek (toxic metals, sedimentation)
*Wegner Creek (lower reaches completely dewatered)
*Flat Creek (used as irrigation "ditch" for water diverted from Dearborn River, sedimentation)

B. Streams Evaluated Further, and Appear to Have Low Potential as Fluvial Grayling Habitat

(Information sources were as in Category A, and additionally as specified, and on-site inspections. Maps of drainages and streams are in Appendix III.)

RED ROCK-BEAVERHEAD DRAINAGE

Red Rock River, Lower Red Rock Lake to Lima Reservoir

Description: About 29 miles of meandering, low gradient stream are present, with non-winter mean annual stream flow of 130 cfs (Parrett et al. 1989).

Trout present: brook and cutthroat trout.

Advantages: This is a low gradient, meandering stream section. Brown and rainbow trout are not present.

This part of the river is partially isolated, between a dam upstream at the outlet to Lower Red Rock Lake, and Lima Reservoir downstream. The latter could serve as an ecological barrier, being too warm and shallow during summer for grayling. Potential spawning tributaries would be provided by Long Creek (which has cutthroat and brook trout) and Peet Creek (which has westslope cutthroat trout).

Disadvantages: The stream suffers from high turbidity and siltation. Brook trout are reported present.

Comments: I inspected this site in July, 1992. At two bridge crossings between Lower Red Rock Lake and Lima Reservoir, the stream was very turbid, shallow, and wide, with no pools in sight. The valley floor appears heavily grazed by cattle. Oswald (pers. comm.) is of the opinion that this stream provides poor habitat for stream salmonids. George Jordan (U.S. Fish & Wildlife Service, pers. comm.) floated the stream in August 1992 and sampled some pools with a backpack shocker. He found the entire stream was mostly shallow and turbid, and found only longnose dace (Rhinichthyes cataractae), sculpins (Cottus bairdi) and unidentified sucker fry. No trout were seen.

Evaluation: Although this part of the Red Rock River has advantages of good size, low gradient, and lack of brown and rainbow trout, its present physical condition makes it unsuitable for grayling. High turbidity appears related to its origin in a very shallow lake, Lower Red Rock Lake, in which sediments can become suspended during windy conditions, and by riparian and stream bank erosion.

Odell Creek, above Lower Red Rock Lake:

Description : There are about 7 miles of low gradient stream between the bridge on main refuge road and the lake, with mean annual flow of 18 cfs (Parrett et al. 1989).

Trout present: brook and cutthroat trout.

Advantages: This stream is believed to have supported indigenous fluvial grayling. Cutthroat trout are present. It is located on the Red Rock National Wildlife Refuge, and grayling restoration should be compatible with refuge objectives.

The average gradient of the entire stream is 1.6 %, but is probably less than 1 % in the lower reaches.

Disadvantages: Brook trout are present. Except for beaver dams, there is unimpeded access to Lower Red Rock Lake downstream

Comments: I inspected this stream in July, 1992. The section below the road bridge is low gradient, with numerous deep pools. Much of the substrate was silted. This tributary is used by spawning grayling, which apparently come all the way from Upper Red Rock Lake, and it is possible that there are a few resident grayling in the stream (MDFWP 1981; Ron Skates, U.S. Fish & Wildlife Service, pers. comm.)

Evaluation: Because of its function as a spawning tributary for the indigenous population of grayling in Upper Red Rock Lake, and the possibility that there may be a few resident grayling present, Odell Creek should not be considered for plantings of fluvial grayling. Emphasis should be on sampling to determine whether there are grayling present outside of the spawning season, and to manage the stream to maintain and enhance its use as a spawning tributary for Red Rock Lake grayling.

JEFFERSON RIVER DRAINAGE

Halfway Creek, tributary to Big Pipestone Creek

Description: There are two miles of low to moderate gradient stream (0.5-1.0%) above a natural barrier.

Trout present: westslope cutthroat trout, possibly genetically pure

Advantages: The stream is isolated above a barrier, and only westslope cutthroat trout are reported present.

Disadvantages: The stream could be important for westslope cutthroat and is capable of supporting few fish (1986 estimate of about 300 total cutthroat trout).

Comments: This stream was evaluated despite its small size because it contains only native westslope cutthroat and is isolated above a barrier falls. I inspected the section within the National Forest boundary in August 1992. It is a very small stream with few pools.

Evaluation: This stream is probably too small and shallow to provide habitat for fluvial grayling.

Upper Gallatin River, between reaches near Fan Creek (Yellowstone National Park) and Taylor Fork

Description: This reach is about 15 miles in length, with gradient of about 0.6 to 0.8%. The mean annual discharge much further downstream, above the West Fork, was estimated at 454 cfs (Farnes and Shafer 1972, cited in MDFWP 1989). Mean discharge in this part of the river is substantially lower, probably less than 200 cfs.

Trout present: Rainbow trout predominate, and small numbers of cutthroat, brook and brown trout are present. All are present in relatively low densities (Vincent pers. comm.).

Advantages: This part of the Gallatin River may have once supported grayling. Elrod (1931) mentioned the presence of grayling in Fan Creek. Although he was discussing the Madison drainage, the Fan Creek referred to may have been the tributary to this part of the upper Gallatin River. This would represent relatively recent persistence of grayling in the Gallatin River drainage, but it is not known whether the fish were native or planted. These reaches are in public lands, either Yellowstone National Park or Gallatin National Forest, and are closely paralleled by a highway. Trout population densities are low (Vincent pers. comm., Kaeding pers. comm.).

Disadvantages: Non-native rainbow trout are present, and small numbers of brown trout.

Comments: I visited this site in July 1992. For about two miles above Fan Creek, the river has low gradient and is meandering, with many backwater areas and side channels created by beaver activity. However, only few pools are present. The stream appears biologically unproductive, with very clean substrate and absence of macrophyte beds. The gradient increases further upstream and the stream becomes smaller and shallower. The river appears doubled in volume with the entrance of Fan Creek. Between Fan Creek and Taylor Fork most of the river length is shallow, wide, and riffle-like with clean substrate of pebbles and cobbles. Relatively few pools are present.

The short section between the Yellowstone National Park boundary and Taylor Fork was the site for an experimental plant of about 5,400 grayling in July 1992. These fish were 4 to 8 inches in length and were reared at the Bozeman Fish Technology Center from gametes stripped from grayling captured in the Big Hole River. Fishermen reports indicate that these grayling moved downstream from the release site and, as of October 1992, appeared concentrated in the lower Gallatin River west of Bozeman (Byorth pers. comm., Vincent pers. comm.).

Much larger numbers of about 24,000 to 46,000 grayling per year, 2 to 6 inches in length, were stocked in the upper Gallatin River from 1938 to 1941 (Tyron 1947). These grayling were from a lacustrine source. Some of these planted fish remained in the area and supported a temporary fishery for a few years, but were gone by 1945 and 1946.

Evaluation: The upper Gallatin River does not appear to provide good grayling habitat because of the few pools present in these reaches. Most of the stream is wide and shallow and flows over clean, coarse substrate without beds of macrophytes. The recent, July 1992 experimental plant of Age-1 Big Hole River grayling was instructive, and appeared to confirm that even fluvial grayling will tend not to remain in a stream with such characteristics. Therefore, it would seem more appropriate to use other streams for future experimental plants of fluvial grayling.

MADISON RIVER DRAINAGE

Grayling Creek, tributary to Hebgen Reservoir

Description: About 9.5 miles of moderate gradient stream, averaging about 1.1%, are located above a canyon. This entire reach of stream is within Yellowstone National Park, and the canyon is about 4.9 miles above the park boundary. Flow in September 1970, near the park boundary, was 48.3 cfs (Dean and Mills 1971). Dean and Mills (1971) reported the presence of a vertical, 4-5 ft cascade in the canyon. However, Dean and Varley (1974) reported that this barrier had been cut through by the river and was no longer effective.

Trout present: cutthroat, cutthroat-rainbow hybrids, and brown trout.

Advantages: The stream is located within Yellowstone National Park, and YNP policy favors conservation and restoration of native species. About five miles of this section is paralleled by Highway 191, which would facilitate planting and monitoring of fish. Grayling were native to the stream, although probably only in lower gradient, downstream reaches close to present Hebgen Reservoir. These lower reaches contain brown trout. Above the canyon, cutthroat trout are the predominant salmonid, with only small numbers of rainbow and brown trout.

Disadvantages: The 1.1% average gradient may be somewhat steep. Surveys of this part of Grayling Creek have concluded that pool:riffle ratios are low amd biological productivity is low (Dean and Mills 1971, Jones et al. 1983).

Comments: I inspected this site in July 1992, from within the canyon to about five miles upstream, where the stream turns to the east, away from Highway 191. General appearance of the stream was consistent with the earlier descriptions cited. The stream is mostly wide and shallow with relatively few pools except near Highway 191 at its northernmost crossing of the stream. For about 0.4 miles in each direction from the highway crossing, deep pools are common. Productivity appears low, with relatively little periphyton growth on the substrate and macrophytes nearly absent.

Over 600,000 grayling originating from Grebe Lake were stocked into Grayling Creek from 1934 to 1942 (Dean and Mills 1971). They seemed to disappear soon after being planted.

Evaluation: Because of its moderate, rather than low, gradient and its low ratio of pools, this stream appears only marginally suitable as grayling habitat. Large, deep pools are common only within about a mile of stream, above and below the northernmost crossing by Highway 191. It has low biological productivity and supports a low density of trout. This stream was once considered as a site for grayling restoration within Yellowstone National Park, because it appeared to contain only cutthroat trout and was isolated above a barrier. However, with the erosion of the barrier allowing upstream colonization by brown and rainbow trout, this stream was considered no longer suitable (Dean and Varley 1973). More recent surveys have confirmed the presence of brown trout (Jones et al. 1983, 1991). Earlier plants (1934-1942) of large numbers of lacustrine grayling failed to establish any presence of grayling in the stream. Because of its apparently marginal habitat with relatively few pools, and its colonization by brown trout, this part of Grayling Creek does not appear to provide a site with high potential for restoration of fluvial grayling.

South Fork of the Madison River

Description: This is a former tributary of the Madison River, but now flows directly into Hebgen Reservoir. Of its approximately 16 miles of total length, about 10 miles of its lowest reaches have gradients of 0.2 to 0.4%. Mean annual flow is about 140 cfs (Parrett et al. 1989). Elevation at Hebgen Reservoir is 6530 ft.

Other trout present: Brown, rainbow, cutthroat and brook trout are present, with a large predominance of brown trout in the lower reaches. A 1971 estimate near the confluence with Hebgen Reservoir yielded an estimate of about 1,393 brown trout per 1000 ft (7,355 per mile), with about 96% being young of year. Only small numbers of rainbow and brook trout were present.

Advantages: This is a fairly large stream with low gradient and many deep pools. This may have been an important grayling stream. Elrod (1931) described grayling as the "principal fish in the South Fork of the Madison". Remnant grayling may have been present until 1975 (Holten, unpublished notes to files, MDFWP), although these may have resulted from planted fish.

Disadvantages: Brown trout are the predominant trout in these lower reaches, with fewer rainbow and brook trout. The stream is contiguous with Hebgen Reservoir. These lower reaches also provide important spawning habitat for trout from Hebgen Reservoir (Vincent, pers. comm., Nick Hetrick, U.S. Forest Service, pers. comm.)

Comments: I inspected different sections of this stream above and below the Highway 91 bridge in August and September, 1992. The stream is low gradient, meanders through willow thickets, and has many large, deep pools. Riffle areas have clean gravel and pebble substrate, with very little macrophyte growth.

Evaluation: Physically, the South Fork of the Madison appears to fulfill important criteria for a grayling stream. It has relatively good volume, is low gradient and meandering, and has an abundance of deep pools. Its apparent suitability for grayling is supported by accounts of their former presence. However, the stream is now a tributary of Hebgen Reservoir, without any barriers to prevent grayling from moving downstream into the reservoir or movements of trout upstream. The very low gradient of these lower reaches would make it difficult to construct a barrier (Vincent, pers. comm., Hetrick, pers. comm.). Brown trout are common both in the reservoir and lower reaches of the stream.

Given the predominance of brown trout in this part of the stream and in Hebgen Reservoir, and the lack of a barrier or suitable site to construct a barrier, prospects for successful restoration of fluvial grayling into the South Fork of the Madison or into Hebgen Reservoir do not appear favorable. Hebgen Reservoir has fewer areas of dense macrophyte beds in shallow water than does Ennis Reservoir. Such macrophyte beds appear to be very important to grayling in Ennis Reservoir (Vincent pers. comm.). In the South Fork, as with other former grayling streams, we need to ask whether there is any evidence that conditions have improved for grayling since they were locally extirpated. Unless the major factor was fishing overharvest, not likely given the brushy thickets through which much of the stream flows, the answer appears to be negative. Establishment of brown trout and the creation of Hebgen Reservoir may have been major contributors to the decline and disappearance of grayling from this stream, and both factors are still present.

MISSOURI RIVER BETWEEN CANYON FERRY RESERVOIR AND GREAT FALLS

Elkhorn Creek, tributary to Holter Reservoir

Description: About 2 miles of low gradient stream are present above its confluence with Willow Creek. A rock barrier was built on the stream to isolate its westslope trout population from downstream migrants. Flow is only several cfs (MDFWP 1989b)

Trout present: westslope cutthroat, possibly genetically pure.

Advantages: The stream above the barrier is occupied only by a population of reportedly pure westslope cutthroat trout, isolated above an artificial barrier.

Disadvantages: It has a very small discharge volume, of several cfs.

Comments: I inspected this site in July 1992. The stream is very small and shallow, with few pools except for numerous beaver ponds. The rock drop-barrier appears in good condition.

Evaluation: Because of its very small size, relatively few pools except beaver ponds, and extensive series of beaver dams, this stream does not appear to provide good habitat for fluvial grayling.

SMITH RIVER DRAINAGE

South Fork Smith River

Description: There are about 42 miles of mostly low gradient waters, with low flows of only several cfs.

Trout present: brook trout and a few brown trout.

Advantages: This was likely native habitat for fluvial grayling, and has a low gradient.

Disadvantages: The stream flows through private land, irrigation diversions are present, it has a small discharge volume, and it has a moderately popular fishery for trout (mostly brook trout).

Comments: I inspected this site in July 1992, at several bridge crossings near White Sulfur Springs. The stream is very shallow, with a very small flow visually estimated at only several cfs, with silted substrate, and much macrophyte growth. Pools were not evident.

Evaluation: This stream appears too small and shallow to provide good habitat for fluvial grayling.

Newlan Creek below Newlan Reservoir

Description: There are about 9.5 miles of low gradient stream from Newlan Reservoir to its mouth at Smith River. Low flows are only several cfs.

Trout present: brook trout and a few rainbow trout.

Advantages: The lowest section near its mouth may have been native habitat for fluvial grayling

Disadvantages: It has only small discharge volume, and is located entirely on private land. The reservoir above has non-native rainbow trout (in addition to cutthroat trout). There are no barriers from the Smith River.

Comments: I visited this site in July, 1992. It is small and shallow, with very small disharge volume. Below the reservoir, an adjacent diversion canal contained more water than the creek.

Evaluation: Because of its small size and the presence of rainbow trout in the reservoir above, which would provide a continual source of trout into the creek, Newlan Creek does not offer good habitat for fluvial grayling.

C. Streams that Come Closest to Meeting Criteria, and Appear to Provide the Best Potential Habitat for Fluvial Grayling

(Information sources were as with Category A, and additionally as specified, and on-site inspections.)

MADISON RIVER DRAINAGE

Firehole River above Kepler Cascades (Fig. 2)

Description: This part of the Firehole River is described by Jones et al. (1978, 1992). There are about 6.2 miles of low gradient stream, averaging about 0.5%, from Kepler Cascades upstream to canyon reaches above Lone Star Geyser. The first 2.5 miles, to Lone Star Geyser, have slightly steeper gradient averaging about 0.8% and are paralleled by a park road and trail. The stream is barren of fishes above this 6.2 mile reach. Elevation at Kepler Cascades is 7500 ft. Flow at this location ranges seasonally between about 28 to 215 cfs (Burkhalter 1979).

Trout present: brook trout and some brown trout.

Advantages: This part of the stream is partially isolated between a waterfall and upstream reaches barren of fishes. Location is within Yellowstone National Park, and park policy favors conservation and restoration of native species. Release and monitoring of fish would be facilitated by presence of a service road which parallels 2.4 miles of the section. Despite its high elevation, water temperatures are moderated by small amounts of geothermal inputs, which prevent freezing during winter but do not warm stream higher than about 68 F during summer (Burkhalter 1979).

Disadvantages: Non-native brook trout and a few brown trout are present. Chemical treatment to reduce these fish may be prevented by the circumstance that the water intake for Old Faithful area is within the lower end of this stream section.

Comments: I inspected this site in August, 1992, from the water intake to about 0.25 mile above Lone Star Geyser. Pool:riffle ratio appears good, with pools present throughout the 2.5 mile section. An especially large pool is formed by a small diversion structure at the water intake near the downstream end. Beds of macrophyte vegetation are common. Substrate is varied, from bedrock to gravel to silt in the slowest reaches.

Except for the short section between the Madison River and first cascades upstream, the Firehole River was barren of fish until stocking of trout began in 1889. In this uppermost section above Kepler Cascades, brook trout are presently the predominant fish, with smaller numbers of brown trout (Jones et al. 1978, Kaya and Kaeding 1979, Kaeding 1980). Population densities have not

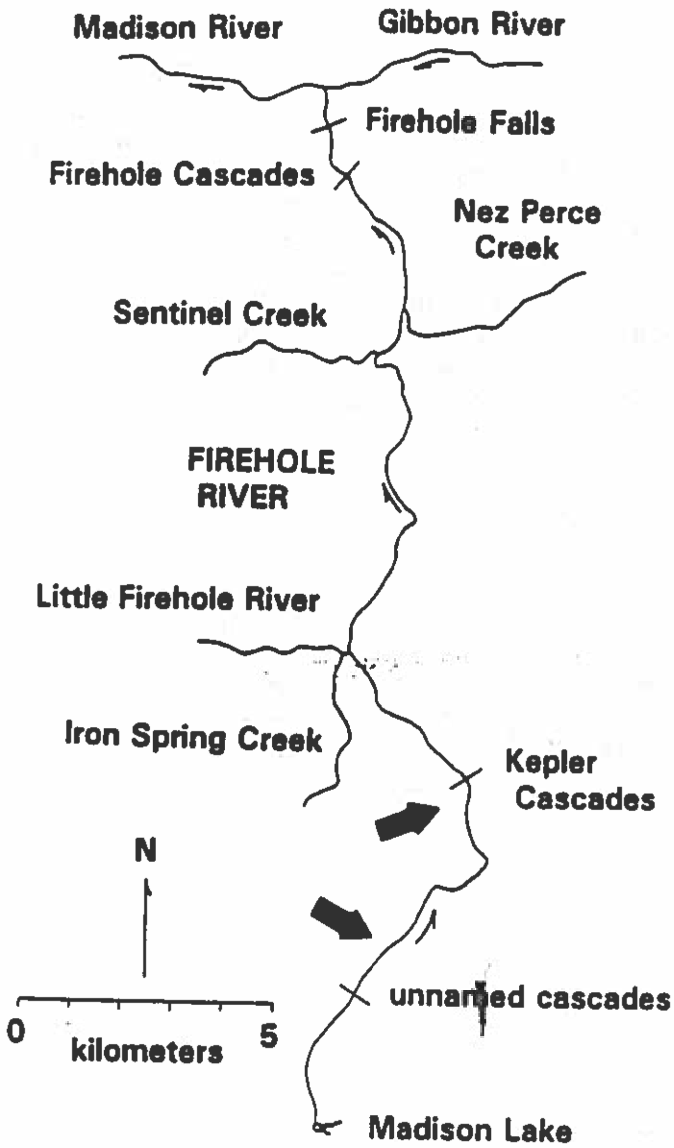


Figure 2. Firehole River and tributaries (modified from Jones et al. 1992). Discussed as a potential restoration site for fluvial grayling is the reach from Kepler Cascades to unnamed cascades in upstream, canyon sections.

been estimated in these reaches, but fish growth is slow, with brown trout estimated to be about 7.3 inches at annulus III (Kaeding and Kaya 1979).

Evaluation: This part of the Firehole River appears to offer favorable physical habitat for fluvial grayling, in a setting of physical isolation above a barrier and location within a National Park. The presence of brook trout and lesser numbers of brown trout are the obvious detractions. Brook trout have predominated over brown trout for decades, since at least the 1950's (Benson et al. 1959). This resembles the long predominance of brook trout over brown trout (and grayling) in the upper Big Hole River, a situation in which fluvial grayling have persisted. Population sizes of the currently resident brook and brown trout are not known, and it is thus difficult to estimate the numbers of grayling which could potentially reside in this stream. However, from the general appearance and size of the stream, it would seem realistic to hope for a population of at least several hundred adults. While this would be a very small population, the existence of any additional population would represent a significant improvement over the current status of fluvial Montana grayling.

Ideally, plants of grayling into this stream should be preceded by treatment to eliminate or severely reduce the non-native brook and brown trout. However, chemical eradication of brook trout would be made difficult by their presence in small tributaries in the area (Jones et al. 1978). Another likely obstacle to chemical treatment is the circumstance that this part of the stream provides drinking water for the Old Faithful visitor and recreational complex. Even if treatment to greatly reduce non-native densities is deemed to be prohibitive, however, either physically or administratively, this part of the Firehole River could still be considered for an experimental plant of grayling. In such case, grayling would be stocked into the present non-native salmonid community as an experiment to determine whether grayling can become established in such a situation.

Gibbon River, Upstream from Gibbon Falls and Upstream from Virginia Cascades (Fig. 3).

Description: Two sections are considered. The lower is 11 miles of stream with gradient averaging about 0.2%, from Gibbon Meadows (above Gibbon Falls) to about two miles above the Norris Campground. Mean stream flow from May 7 to August 19, 1973, was 71 cfs near the campground (Dean and Varley 1973). Elevation at the lower end of Gibbon Meadows is 7400 ft. The second, upper section is about 1.6 miles of stream with gradient of about 0.5%, in Virginia Meadows above Virginia Cascades. Mean stream flow in this section was 8.8 to 53.7 cfs in 1963-1965 (Vincent 1967). Elevation at the lower end of this section is 7770 ft.

Trout present: According to electrofishing surveys in 1973, brook trout are predominant in the upper, Virginia Meadows area, with

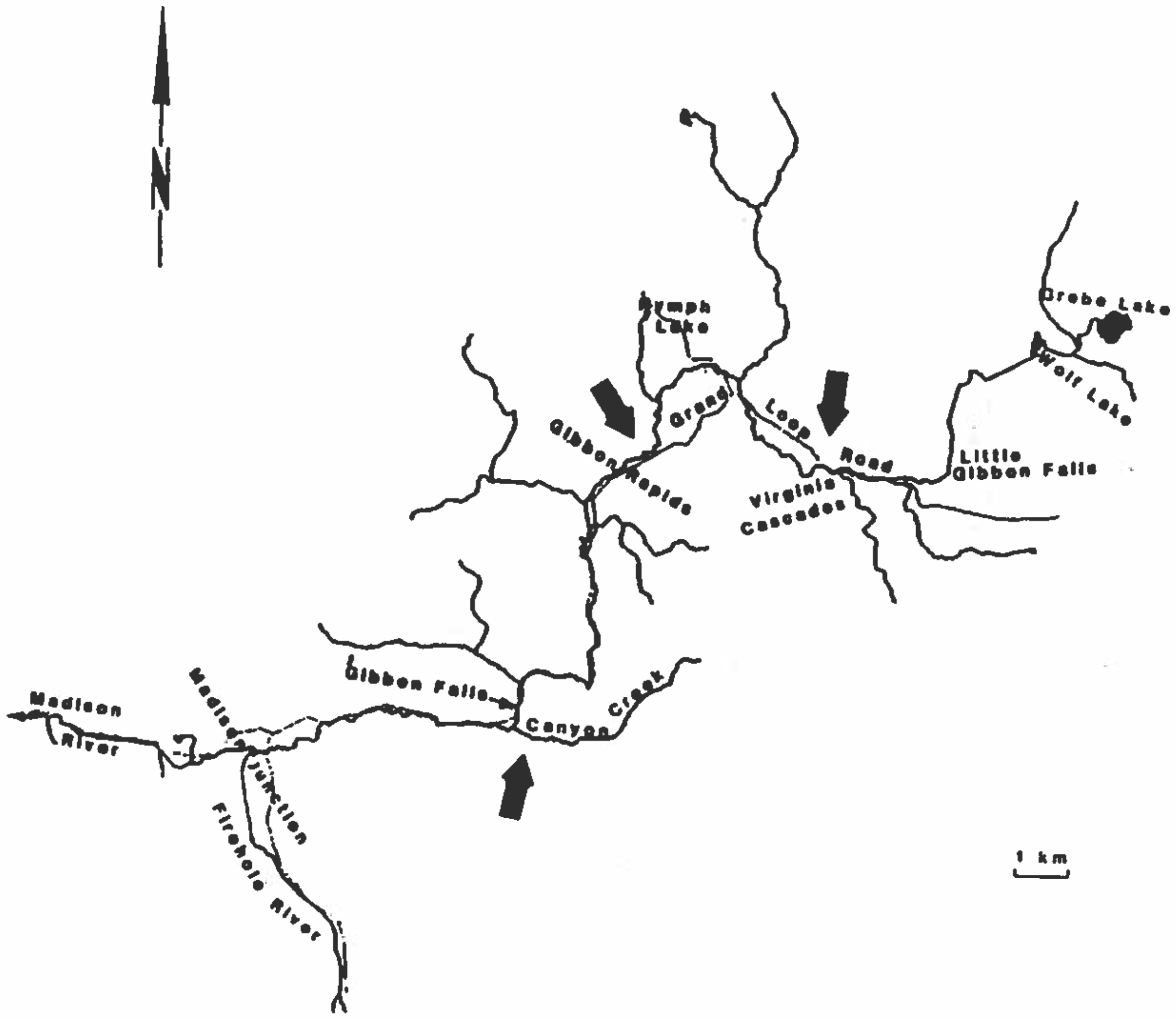


Figure 3. Gibbon River and tributaries (modified from Jones et al. 1991). Discussed as potential grayling restoration sites are reaches above Virginia Cascades, above Gibbon Rapids, and a tributary, Canyon Creek.

a few rainbow trout present. In the lower, 11-mile section, brook trout are predominant above Norris Geyser Basin, with few brown trout present, but brown trout are predominant in the Gibbon Meadows area (Dean and Varley 1974).

An electrofishing survey in 1990 yielded 7 rainbow and 262 brook trout in a 0.15 km section of the upper reaches of the Gibbon River above Virginia Meadows (Jones et al. 1991). The rainbow trout population was estimated at 566 trout/km (906/mile). The brook trout population was not estimated but would be substantially higher, given the brook:rainbow ratio of 262:7 captured.

Grayling were once present in these sections of the Gibbon River, resulting from plants into the stream (Varley 1981), and also probably from downstream drift after they were introduced and became established in Wolf and Grebe lakes in the drainage. Seamans (1940) reported that grayling were found above Gibbon Falls and in Virginia Meadows. Benson et al. (1959) reported that grayling were common above Virginia Cascades.

Advantages: Brown trout are absent from the upper section, above Virginia Cascades, and are uncommon in the upper half of the lower section. Much of these reaches of the Gibbon River are readily accessible by park highways, which would facilitate planting and monitoring of fish. The location is within Yellowstone National Park, and park policy favors conservation and restoration of native species. Except for nearby roads, the stream sections are in a completely natural state, with no diversions or other artificial structures present.

Disadvantages: Non-native brook trout are present, and are abundant in the Virginia Meadows section. Brown trout are predominant below Norris Geyser Basin.

Comments: These sections of the Gibbon River were inspected in August 1992. Both upper and lower sections are low gradient and meandering, with deep pools common. Little macrophyte vegetation is present, except in the Elk and Gibbon Meadows reaches below the Norris Geyser Basin. Trout, presumably brook trout, were readily visible and abundant in the Virginia Meadows area.

Grayling have not persisted as a self-sustaining population in the Gibbon River despite past plants of grayling into the stream and despite the presence of lacustrine populations above. Recent observations on Ennis Reservoir confirm that grayling will move downstream from a lacustrine population (Byorth pers. comm., Byorth and Shepard 1990), and it is thus likely that grayling have continually entered the upper Gibbon River from the lakes.

Evaluation: Both these reaches of the Gibbon River appear to provide favorable physical habitat for fluvial grayling, but are inhabited by non-native trout. The lower, 11-mile reach contains brown trout in its lower reaches below Norris Geyser Basin and thus appears unsuitable for grayling. The short, 1.6 mile reach in Virginia

Meadows (Fig. 4) is populated by brook trout and a few rainbow trout and is isolated above a waterfall. Since grayling presently persist in the upper Big Hole River with brook trout and a few rainbow trout, it is possible that they may be able to survive in this part of the Gibbon River. Because of its apparently favorable habitat and its trout community of mostly brook trout but no brown trout, the upper Gibbon River in the Virginia Meadows section is a site which should be considered for grayling restoration. The non-native trout could not be eradicated, since they are also present in reaches and tributaries above. However, it may be possible to greatly reduce the present high densities of brook trout in this Virginia Meadows section before introduction of grayling, chemically or by electrofishing removal.

Although this is only a short, 1.6 mile section of stream, it appears to have good biological productivity and supports a high density of trout. If grayling were to be successfully established, a population of at least several hundred would appear feasible. Although modest in total numbers, such a population would be as large as may currently inhabit the Madison River on any extended basis, and would be a great improvement over having a single, fluvial population in the upper Big Hole River. Also, if grayling were to become established in this part of the Gibbon River, fish drifting downstream would have the potential of establishing a population in the meadow reaches above Norris Geyser Basin.

Canyon Creek, tributary of the Gibbon River (Fig. 5)

Description: This stream and the history of attempts to establish grayling in it are summarized in various annual reports of the U.S. Fish and Wildlife Service, Yellowstone Fishery Assistance Office (Dean and Varley 1974, Jones et al. 1981, and the "Preliminary plan for restoration of fluvial Arctic grayling in Yellowstone National Park", 1991).

This is a small, biologically productive stream with about 3.5 miles of low to medium gradient waters between a natural falls upstream and an artificial barrier, constructed in 1975, near its confluence with the Gibbon River. Discharge is about 4 to 7.5 cfs, with gradient in these reaches about 1% or greater. Elevation at the lower end is 6980 ft.

The stream was chemically treated to remove resident brown, rainbow, and brook trout in 1975. About 60,000 grayling were planted in this stream from 1976 to 1981. Of these, 120 were transferred directly from the Big Hole River. All others were from lacustrine sources, planted as eyed eggs or swimup fry, with the exception of 2863 planted as larger (about 9 inch) juveniles. An electrofishing survey in 1980 yielded no grayling and confirmed the reestablishment of a non-native trout community dominated by brown trout (Jones et al. 1981). Recent evaluation of fishermen catches suggest that grayling planted in Canyon Creek moved downstream into the Gibbon and Madison Rivers (Jones et al. 1992).

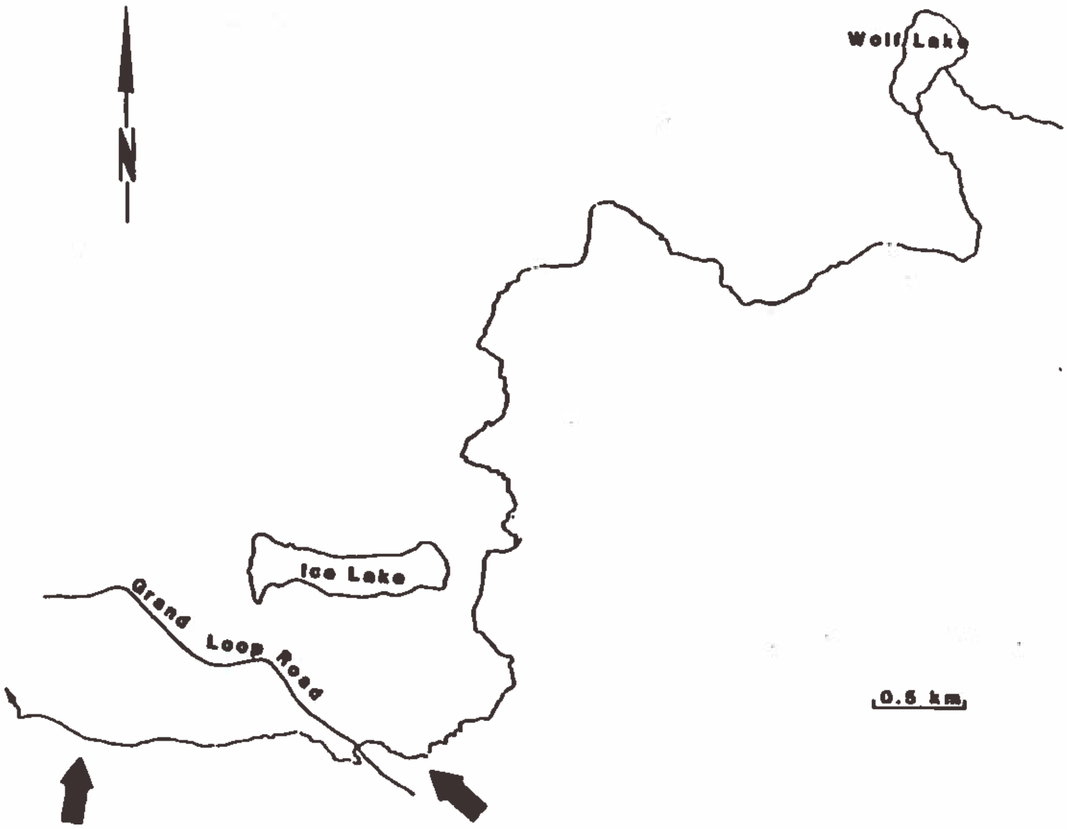


Figure 4. Uppermost reaches of Gibbon River (modified from Jones et al. 1991). Discussed as a potential grayling restoration site is about 1.6 miles of stream from below to above the Grand Loop Road.

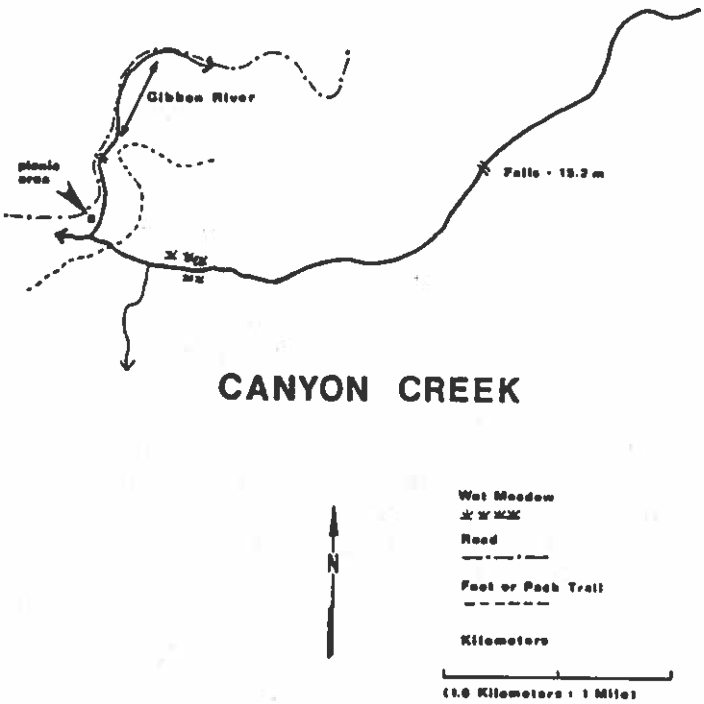


Figure 5. Canyon Creek, tributary of the Gibbon River (modified from Jones et al. 1981).

Advantages: The stream has low to medium gradient, numerous pools, and an artificial barrier to upstream movement by non-native fishes from the Gibbon River. It is biologically productive, known since a century ago to have an abundance of resident trout (Jordan 1891). With the exception of the barrier, no diversions or other artificial structures are present.

Disadvantages: Non-native brown, rainbow, and brook trout are present, with the community dominated by brown trout. This would have eliminated this stream from further consideration were it not for the possibility of chemical treatment to remove these non-natives. Also, this is a relatively small stream with discharge averaging less than 10 cfs. Finally, grayling appeared absent or sufficiently uncommon to escape notice, when Jordan (1891) saw this creek in 1889. Jordan mentioned only trout and sculpin in this tributary of the Gibbon River, despite grayling being common in the river.

Comments: I inspected this site in August 1992. The barrier constructed in 1975 appears still in good shape and functional. Most of the drainage was completely burned over by the fires of 1988. The stream is biologically productive, with an abundance of macrophyte vegetation, substrate covered with periphyton, and fish visible in pools and runs.

Evaluation: This site offers the prospect of fluvial grayling established in a small but productive stream, isolated by both upstream and downstream barriers. Problems with the past, intensive efforts to establish grayling included origin and size of grayling planted, and abundance of non-native trout. Fluvial grayling can now be reared to advanced juvenile sizes and provided in large numbers. Nevertheless, the prospects of establishing grayling would be poor unless the stream were again chemically treated to remove the brown trout. The previous attempt at treatment probably failed to eliminate non-natives from above the barrier, and fish may have somehow gotten past the barrier (Jones et al. 1979). Park fisheries personnel have gained much experience in eradicating fish from a stream since those earlier efforts. This stream should be considered as a site for fluvial Montana grayling introductions only in conjunction with an eradication effort and verification of the structural integrity of the artificial barrier. Even with chemical treatment of the stream, prospects of a self-sustaining population becoming established are questionable. Grayling were either absent from this tributary of the Gibbon River, or sufficiently uncommon to escape notice, back in 1889 when grayling were still common in this part of the Gibbon River (Jordan 1891). However, Jordan described an abundance of cutthroat trout and sculpin. There was no barrier to movement of fish between the Gibbon River and Canyon Creek. This suggests that the stream may be too small, or too steep, or have some other, unknown deficiency relative to grayling.

Cougar Creek, upper Madison River drainage (Fig. 6)

Description: This is a small stream which seeps into the ground and ceases surface flow. There are about five miles of low gradient (0.5 to 0.7%) stream length between canyon reaches upstream and cessation of its surface flow. In this part of the stream, discharge in 1991 ranged from about 3.5 cfs in the upper reaches to 7.5 cfs in the lower reaches (Jones et al. 1992). Elevation at the lower end is 6760 ft.

Trout present: Only fish present are mottled sculpin and westslope cutthroat trout, perhaps slightly introgressed with Yellowstone cutthroat trout (Jones et al. 1992). Electrofishing surveys in 1991 yielded an estimate of 90 to 100 trout/km (144 to 160/mile) longer than 150 mm (6 inches), with about the same density of smaller fish. This was similar to an earlier estimate of about 352 total trout/mile (Jones et al. 1979).

Advantages: This stream is physically isolated and is inhabited only by native westslope cutthroat trout and mottled sculpin, both originally sympatric with fluvial Montana grayling. The stream is in a completely natural state, with no diversions or other artificial structures.

Disadvantages: This is a small, biologically unproductive stream, capable of supporting only a relatively low density of salmonids. If grayling were established, there would probably be a reduction in numbers of cutthroat trout.

Comments: I inspected this site in August 1992, and my impressions were consistent with the description of physical, chemical and macroinvertebrate characteristics of Cougar Creek described in a recent report (Jones et al. 1992). It is a small stream with low gradient and many small pools. Low biological productivity is indicated by its clean and clear appearance, with little periphyton growth on its substrate of mostly coarse sand and gravel, and only little macrophyte growth in some pools. Small trout were visible in pools.

Evaluation: Cougar Creek has, on a small scale, an appropriate physical combination of low gradient and good availability of pools, combined with the biological attraction of containing only native cutthroat trout and sculpins. Of the streams surveyed and evaluated, only Cougar Creek offers the opportunity to re-create a native mixture of westslope cutthroat trout and Montana grayling without extensive chemical eradication of non-natives.

Another attractive feature is the complete barrier to both upstream and downstream movement provided by its cessation of surface flow. Past experiences, including in nearby Canyon Creek, suggest that even fluvial grayling may not be inclined to remain in such a small stream of less than 10 cfs. However, grayling could not leave Cougar Creek and would be forced to remain in the stream. This would, therefore, present an opportunity to determine whether a

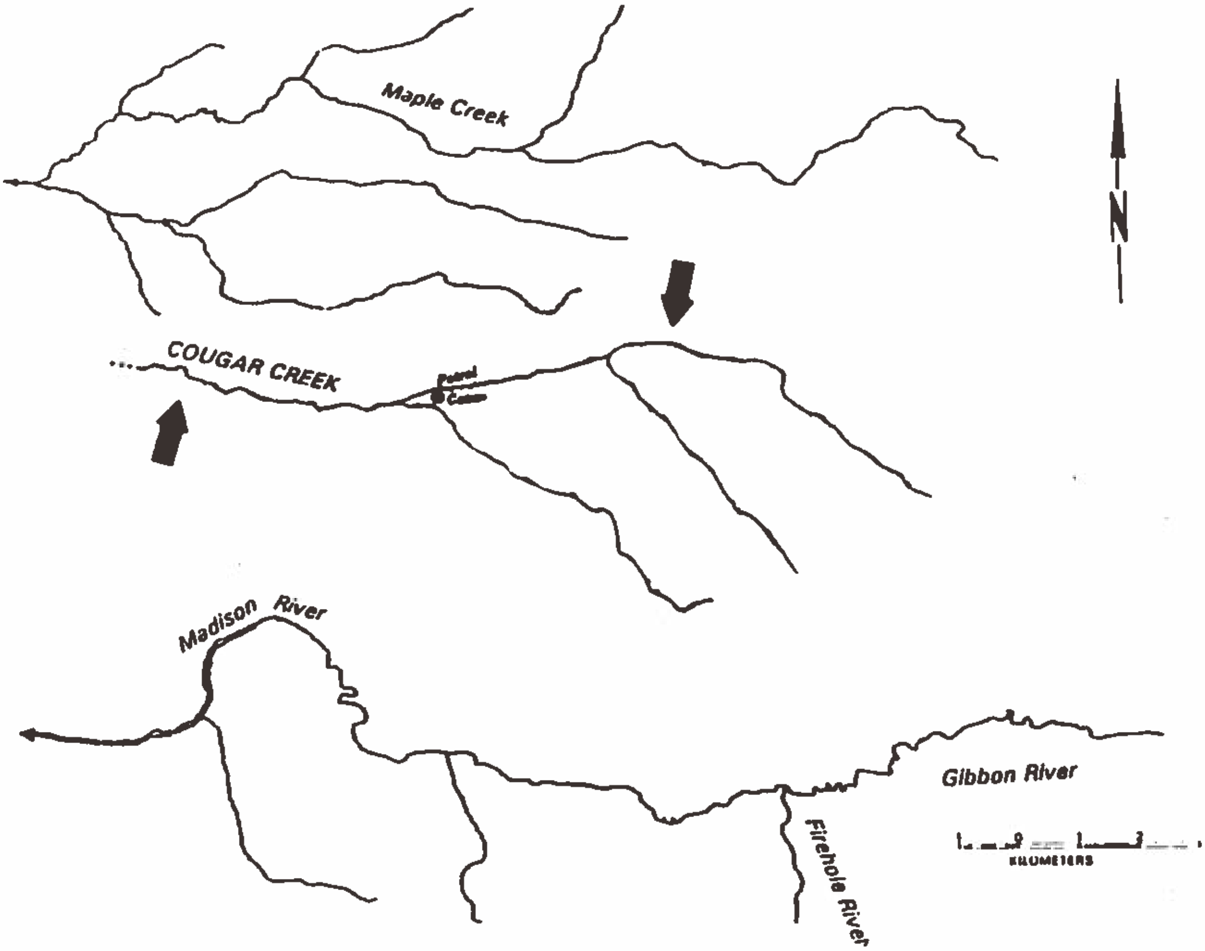


Figure 6. Cougar Creek, and location relative to Maple Creek and the Madison River (modified from Jones et al. 1992). Discussed as a potential grayling restoration site is about 5 miles of stream from below to above the National Park Service patrol cabin.

population of grayling can become established in a small stream from which they cannot migrate and which is inhabited only by sympatric native fishes. For these reasons I concur with the opinion of the U.S. Fish and Wildlife Service biologists for Yellowstone National Park, Ron Jones and Lynn Kaeding, that an attempt should be made to establish grayling in this stream. Even if grayling were to become established in this stream, it is likely that population density would be less than 100 age-1+ per mile within the five stream miles available, and that fish would be small, probably averaging less than 10 inches as adults. However, even such a modest population would represent a significant improvement in the status of fluvial Montana grayling.

Cherry Creek (Butler Reach on the Turner Ranch), tributary to the lower Madison River (Fig. 7).

Description: Cherry Creek enters the lower Madison River, downstream from the Highway 289 bridge. A middle reach of Cherry Creek, known as the Butler Reach, is partially isolated between a waterfall downstream, and a section upstream that seeps into the stream bed and goes dry except during periods of high flows (Chris Francis, ranch fish manager, pers. comm.). Stream flow is restored at the head of the Butler Reach by large volume of surface discharge. Mean annual flow of Cherry Creek is 52 cfs (Parrett et al. 1989) near its mouth; flow in this middle section has not been measured but appears somewhat less. The section provides about two miles of stream with a gradient of about 1%. Elevation at the lower end is 5400 ft. Extensive habitat modification was conducted on this reach in 1990, resulting in enhancement of pool habitat.

Trout present: Electrofishing surveys of two sections of the Butler Reach were conducted in 1990, prior to stream modification work (Inter-Fluve 1990). High densities of rainbow and brook trout were present. Estimates of Age II or older trout were about 3500/mile in one section (50% rainbow trout) and 4780 trout/mile in the other (63% rainbow trout). These Age II or older trout ranged from about 5.5 to 11 inches in total length.

Advantages: The downstream waterfall is a barrier preventing movement of brown trout into this middle reach. This portion of the stream is entirely on private land, and the landowner, Ted Turner, seems interested in the concept of restoring the salmonid community to a native combination of cutthroat trout and grayling (Joe Urbani, Inter-Fluve, and Chris Francis, pers. comm.). High biological productivity of the stream is indicated by the high densities of non-native rainbow and brown trout present before stream modification was carried out in 1990. Although post-modification population estimates have not been made, carrying capacity has probably been increased. A ranch road parallels this reach, providing easy access for planting and monitoring of fish.

Disadvantages: Although the stream goes dry above the Butler Reach for much of the year, it is active during high flow periods.

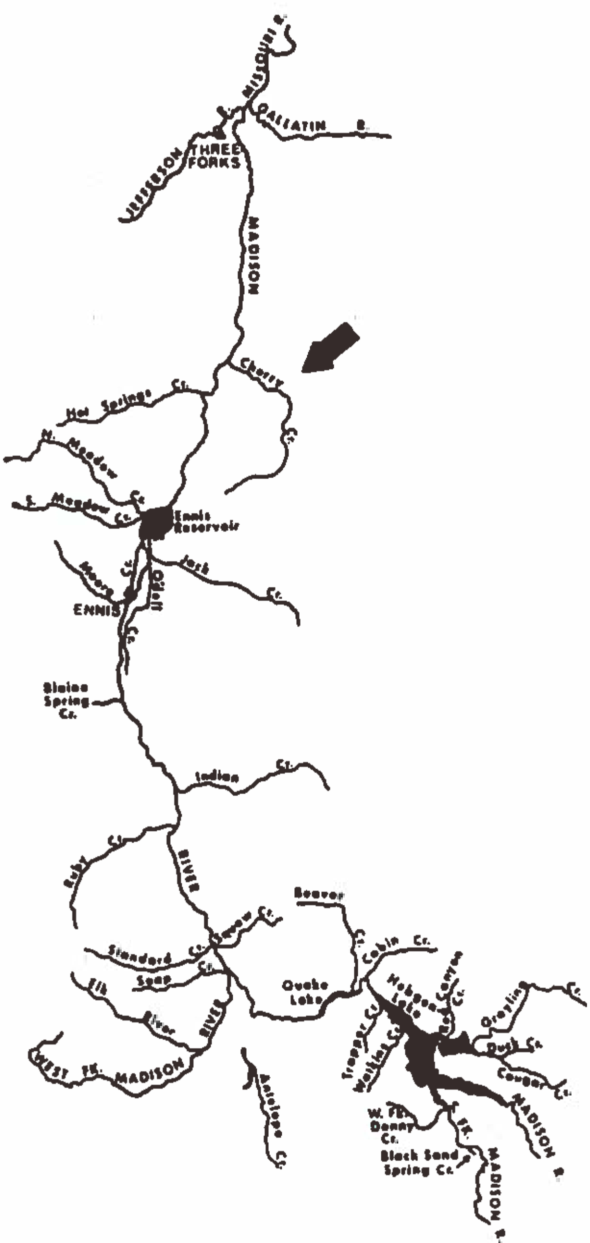


Figure 7. Madison River and tributaries (from MDFWP 1989a). Discussed as a potential grayling restoration site is about 2 miles of Cherry Creek known as the Butler Section (approximate location indicated by arrow).

This would allow movement of fish from upstream reaches down into this reach. High densities of rainbow and brook trout are present. Stream length available is only about two miles.

Comments: I visited this stream in September, 1992, in the company of Chris Francis, fishery manager for the ranch. A succession of large, deep pools have been created by the modification project of 1990. The result is a combination of low gradient, abundance of large pools, and apparent high biological productivity that would seem to offer good habitat for fluvial grayling.

I also examined a reach of stream above the dry section, and saw many brook trout. According to Chris Francis, some rainbow trout are also present.

Evaluation: The Butler Reach of Cherry Creek appears to have suitable habitat for fluvial grayling, in a stream section with summer flows that may be about 20 cfs. However, the large numbers of rainbow and brook trout could present a serious problem to any effort to establish grayling and cutthroat trout. Chemical treatment of the stream would be facilitated by the discrete, surface origin of the Butler Reach. The resident fish manager expressed reservations about chemical treatment. Also, chemical treatment could only reduce, and not eliminate, non-native trout, since such fish are present upstream and could gain access to the Butler Reach during periods of high flow.

This Butler Reach of Cherry Creek thus appears to have good potential as a site for experimental stocking of fluvial grayling and westslope cutthroat trout. Obviously, it would be necessary to discuss and negotiate with the landower, the prospect of chemical treatment to substantially reduce the rainbow and brook trout, as well as subsequent stockings with grayling and cutthroat trout. If grayling were established in this stream, and maintained a population density equal to about 33% of the trout estimated in 1990, then this would be about 1200 Age 1+ grayling/mile, or about 2400 in the two miles available. This would be within the range of estimated number of Age 1+ grayling now present in the entire Big Hole River.

JEFFERSON RIVER DRAINAGE

Upper Ruby River and lower reaches of East, Middle, and West Forks (Fig. 8)

Description (from MDFWP 1989): There are 41 miles of river length between the convergence of the three forks and Ruby Reservoir, with roughly the upper half within the Beaverhead National Forest. Mean gradient is 0.7%. Mean annual flow at a station above the reservoir is 177 cfs, with base winter flow of 102 cfs. Elevation about midway through the section, at the Vigilante Ranger Station, is 6120 ft.

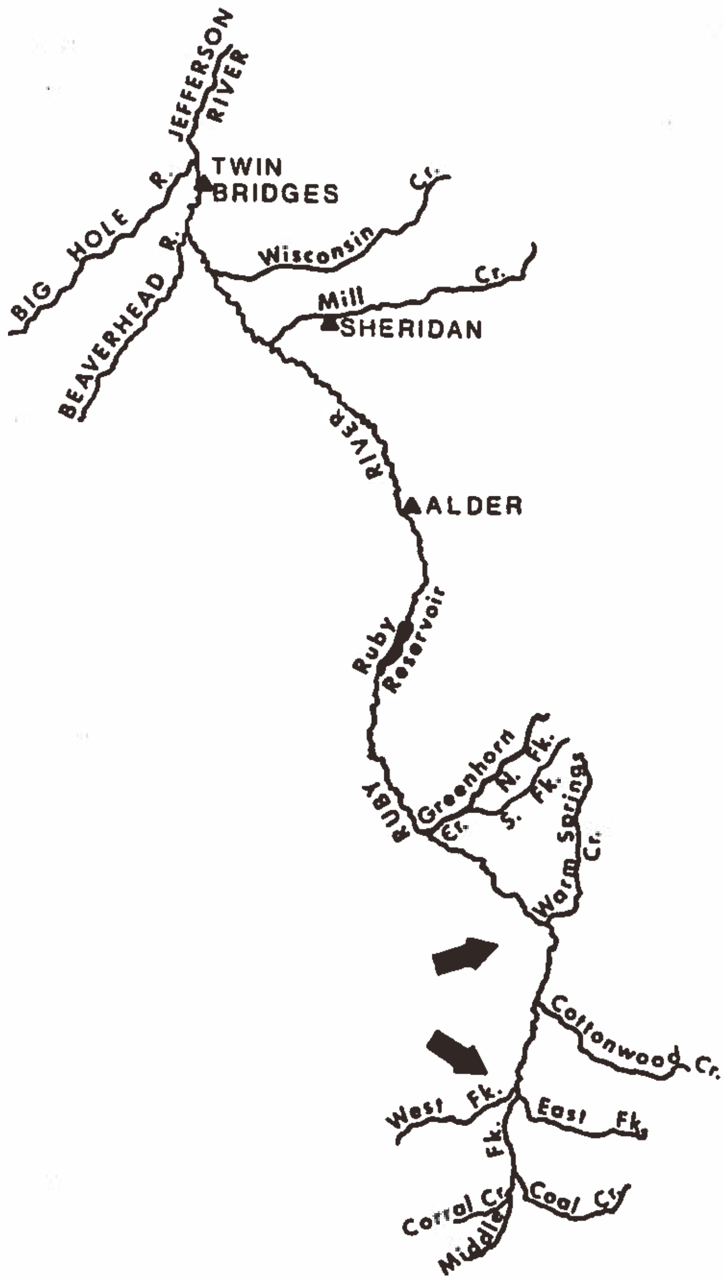


Figure 8. Ruby River and tributaries (from MDFWP 1989a). Discussed as a potential grayling restoration site is about 20 miles of stream from the National Forest boundary near Warm Springs Creek to the confluence of the West, Middle, and East forks of the Ruby.

Trout present: A 1976 survey of a section at the USFS boundary and downstream from Warm Springs Creek yielded an estimate of 565 trout/1000 ft (2983/mile), 97% rainbow trout and the remainder brown trout. This section near the entrance of Warm Springs Creek supports the highest densities and biomass of trout in the upper Ruby River; sections above and below have much lower densities and biomass. Although brown trout are present in reaches closest to the reservoir, they become scarce in the middle and upper reaches close to and within the National Forest (Oswald, pers. comm.)

Fall population estimates were conducted in 1987, 1988, and 1989 from the confluence of the three forks of the Ruby downstream for 1.2 miles (Vincent et al. 1990). Estimated total trout density ranged from 241 to 511 trout per mile. Composition was 32% rainbow, 45% cutthroat, and 23% rainbow-cutthroat hybrid trout. Only two brown trout were collected. Estimated total trout per mile are similar to or higher than estimates of trout and grayling per mile in the Wisdom sections of the Big Hole River.

Advantages: This is among the larger streams within the native range that may still provide potential habitat for restoration of fluvial grayling. With its size, low gradient, and contiguity with the Beaverhead River, this stream almost surely supported indigenous grayling, at least in its lower reaches close to the confluence with the Beaverhead River. Except near the reservoir, brown trout are present in very low densities. Rainbow trout is the dominant salmonid, but present in relatively low densities except close to the entrance of Warm Springs Creek. Public roads parallel much of the river and its tributaries, and would facilitate plantings and monitoring of introduced grayling. Upper reaches close to or above the Forest Service boundary would be above most or all irrigation diversions.

Disadvantages: Non-native rainbow and brown trout are present. There are no barriers to prevent movement of fish between the reservoir and the Ruby River above. Fish from the reservoir, including brown trout, ascend the river to spawn (Oswald, pers. comm.).

Comments: This stream was suggested for consideration by Dick Oswald, because of its physical characteristics and the relatively low densities of non-native trout, except for the section near Warm Springs Creek. I inspected this site in July, 1992. Between the three forks and the Vigilante Ranger Station (U.S. Forest Service), the river has low to moderate gradient, with many large pools. The river appears to have relatively low productivity, as suggested by clean-looking substrate with little macrophyte growth. The lower reaches of the Middle and West forks are also low gradient, meandering streams with many pools but little macrophyte growth. Beaver activity appears high on the tributaries as well as on some sections of the Ruby River below the three forks. Below the National Forest boundary, the gradient becomes even lower, the volume increases, and the pools appear to be more numerous and larger. However, these reaches flow through private land.

Evaluation: The presence of Ruby Reservoir and the presence of non-native trout - rainbow trout throughout and brown trout in the largest, lowest gradient reaches closest to the reservoir - could serve to eliminate this site from consideration. However, as suggested by Dick Oswald, low densities of these non-native trout and the relatively large size of this stream justify further consideration of this site. Haugen (1977, cited in MDFWP 1989a) concluded that reproduction of trout in most spawning areas of the upper Ruby River may be impaired by abundance of fine sediments. If this is an important factor contributing to the generally low densities of trout, then grayling could have an advantage since they do not bury their eggs and do not have the same requirement for highly permeable gravels.

Given the present conditions on the upper Ruby River, the best that could be hoped for would be a situation similar to that existing in the Madison River above Ennis Reservoir. That would be a modest population in which most members inhabit the reservoir while small numbers remain in the river for extended periods. Ruby Reservoir may not provide good habitat for grayling, since it lacks the extensive beds of macrophytes present in other lakes that support good grayling populations in the presence of non-native trout (e.g., Upper Red Rock, Ennis, and Grebe lakes).

The possibility of grayling becoming established in the upper Ruby River could be increased by construction of a barrier above the reservoir. A barrier could be located so that reservoir trout would retain access to spawning areas but be prevented from further upstream movement, and could be located far enough upstream to eliminate most brown trout, which are presently most common in reaches closest to the reservoir. A barrier would also prevent migrations by grayling between the reservoir and the river, and thereby act as a mechanism to select for fish with the highest tendency to remain within the stream. Potential sites for a barrier are probably present in canyon reaches near the National Forest boundary (Oswald, pers. comm.) about 20 river miles upstream from the reservoir. This would still leave about 20 miles of stream above as a potential restoration site for grayling.

It appears that the upper Ruby River offers the best opportunity to restore a population of fluvial grayling on a physical scale similar to that of the upper Big Hole River. Therefore, this stream should be considered as a site for restoration efforts despite its present shortcomings. The most optimistic projection for the upper Ruby River would be that this could provide a site for restoration of grayling in a low gradient, meandering stream with baseline discharge volume exceeding 100 cfs, and with 20 or more miles for spawning and wintering migrations, including low gradient lower reaches of tributaries like the Middle and West Forks. Estimates of trout populations present suggest that this stream may be able to support grayling at densities similar to or greater than the prime grayling sections on the Big Hole River near Wisdom.

SMITH RIVER DRAINAGE

Elk Creek, tributary to Hound Creek, Smith River drainage (Fig. 9)

Description: This is a small tributary of Hound Creek in the Smith River drainage. Gradient at its lowest mile is about 1%, at an elevation of 4600 ft.

Trout present: A MDFWP electrofishing survey in 1971 yielded 35 brook trout and 126 rainbow trout from a 505 ft section near its confluence with Hound Creek. Of these, 11 brook trout and 70 rainbow trout were greater than 5 inches in length, with the largest of both species being 12.2-12.6 inches. This would extrapolate to a electrofishing yield of 1683 trout/mile, with 847 being longer than 5 inches.

Advantages: The lower reaches of this stream are on private land, with the lowest reaches (about two miles?) on the Dana Ranch, whose manager (David G. Cameron) is also a biologist at Montana State University and is very willing to cooperate with grayling recovery efforts. The stream is easily accessed by a ranch road.

Disadvantages: Both rainbow and brook trout are present and relatively abundant. These lower reaches are contiguous with many more miles of stream that eventually originate in the north end of the Big Belt Mountains. No barrier is present to prevent upstream movement of both brown and rainbow trout present in Hound Creek.

Comments: I visited this site in July 1992, together with George Liknes (MDFWP). The lowest reach of this stream appears similar to Canyon Creek, tributary of the Gibbon River described previously . Flow has not been estimated, but appears to be less than 10 cfs. Pools are common, and macrophytes are abundant. A large spring about 0.5 mile from its confluence with Hound Creek appears to provide about 1/3 of the total flow of the stream below. Trout were abundant in the pools.

Evaluation: This site has about a mile of stream which could provide habitat for fluvial grayling. The most serious shortcomings are its relatively small size and the absence of barriers between either Hound Creek or upstream reaches, with waters in both directions populated by non-native rainbow, brook, and (in Hound Creek) brown trout. With extensive upstream reaches of Elk Creek populated by at least low densities of rainbow and brook trout, it would not be practical to attempt chemical treatment to eradicate the non-natives. The unsuccessful results of past attempts to establish grayling in Canyon Creek, Yellowstone National Park, cast doubt on prospects for success in a similar-sized stream like Elk Creek. However, unlike Canyon Creek, brown trout do not appear present in Elk Creek. Elk Creek could serve as an experimental site to determine whether: (1) grayling will remain in a stream with 10 cfs or less; and (2) if grayling can become established despite existing brook and rainbow trout. A ranch road provides relatively easy access to the site for planting fish

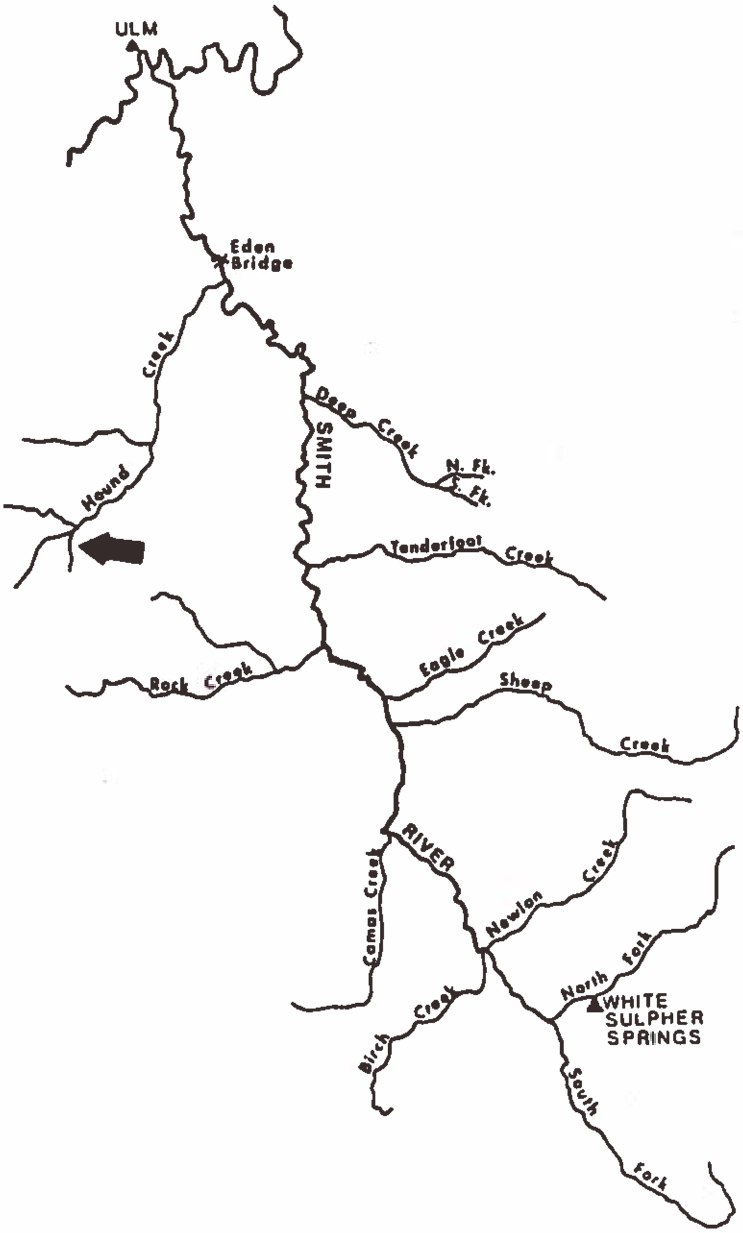


Figure 9. Smith River and tributaries (from MDFWP 1989b). Discussed as a potential grayling restoration site is Elk Creek (indicated by arrow), a tributary of Hound Creek.

and monitoring their status. This is the only stream in the Smith River drainage identified as a potential site for grayling restoration.

SUN RIVER DRAINAGE

North and South Forks of the Sun River, above Gibson Reservoir (Fig. 10)

Description: These two tributaries are similar and will be discussed together. Their confluence once marked the beginning of the Sun River, but they now flow into Gibson Reservoir when it is at or near full capacity. These streams were historically barren of fish, because of a former natural barrier at the present site of Diversion Dam a short distance downstream on the Sun River. The North Fork has at least 21 miles with mean gradient of about 0.6%, while the South Fork has at least 13 miles with mean gradient of about 0.7%. Discharge of the North Fork in 1990 ranged from 105 cfs in October to 2630 cfs in May (USGS 1990). The South Fork is not gauged but is smaller. Elevation at the reservoir is 4750 ft.

Trout present: Rainbow, cutthroat, rainbow-cutthroat hybrids, and brook trout are present in both forks (Hill, pers. comm.).

Advantages: Both have relatively long lengths of low gradient stream, with baseline discharges near 100 cfs. The North Fork is lower in gradient than the South Fork (Hill, pers. comm.). There is a small natural barrier on the South Fork, a short distance upstream from the reservoir (Hill, pers. comm.). Brown trout are not present.

Disadvantages: Both have non-native rainbow and brook trout. The North Fork is contiguous with Gibson Reservoir, without barriers to fish movement. Both are relatively remote. The North Fork is entirely within the Bob Marshall Wilderness and access is limited to trails. Access to the middle section of the South Fork, above the low gradient reaches being considered, is provided by a U.S. Forest Service road ending at Benchmark campground and trailhead. The location of these streams would make it difficult to plant large numbers of fish or to monitor the status of planted fish.

Comments: Because of their relative remoteness, I have not inspected the North Fork, and saw the South Fork only in proximity to the Benchmark Campground, above its lowest gradient reaches. The South Fork in this section has moderate gradient, occasional deep pools, and appears low in productivity. The substrate was mostly pebbles, cobbles and bedrock, and had little periphyton growth and no macrophyte beds.

Evaluation: Because of the unimpeded access to Gibson Reservoir, and the presence of non-native trout, these streams do not actually come close to fulfilling the criteria listed. However, they may be the only streams in the Sun River drainage that have any potential for establishment of fluvial grayling. They each have relatively

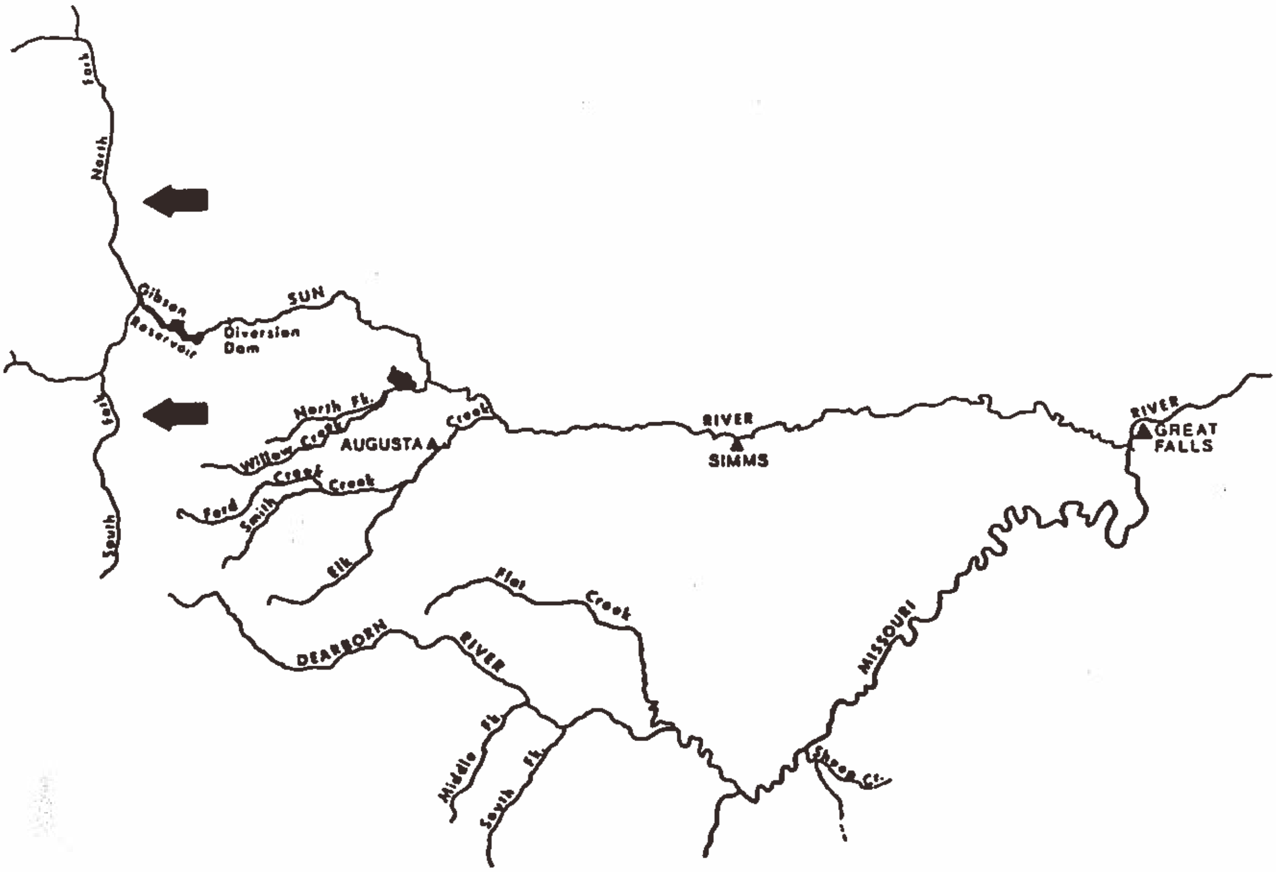


Figure 10. Sun River and tributaries (from MDFWP 1989b). Discussed as potential grayling restoration sites are the North Fork and the South Fork, both above Gibson Reservoir.

long reaches of low gradient stream with low densities of non-native trout. Without having seen the reaches proposed in either stream, I do not know whether they have an abundance of pool habitat. The section near Benchmark Campground on the South Fork did have some large, deep pools, but also appeared to be very low in biological productivity.

Results of the previously described transplant of about 400 grayling into Rock Creek are discouraging. They were taken from a habitat, the Sunny Slope Canal, in which they have to maintain their position in running water. Despite their being planted into a low gradient stream barren of other fishes, they apparently moved downstream into and down the North Fork and failed to establish a population. These results suggest that Rock Creek and the North Fork did not satisfy some habitat requirement.

The North Fork presents a combination of disadvantages: unimpeded access by fish between reservoir and stream, presence of non-native trout, past failure of an attempt to establish grayling in its drainage, and relatively difficult access to the site. These suggest that the North Fork may not be among the more promising sites for fluvial grayling restoration efforts. The South Fork is similar, with somewhat steeper gradient and smaller flow, but has a low barrier that would probably stop grayling, but not trout, from swimming upstream from the reservoir (Hill, pers. comm.).

These advantages are offset only by the scarcity of streams with any suitability as potential sites for fluvial grayling restoration. Both forks should therefore be considered for experimental plantings of fluvial grayling, in considerably larger numbers than the 400 canal fish of the previous attempt.

D. Summary of streams referred to and their deficiencies, among the three categories: streams with serious deficiencies and generally not evaluated further, (*) streams evaluated further but appear to have low potential as grayling habitat, and (**) streams that appear to have the best potential habitat for fluvial grayling. Streams are listed alphabetically within drainages. Maps of drainages and streams are in Appendix III.

Drainage and Stream	Habitat Deficiencies			
	gradient >1%	non-native trout	lake access	degraded habitat
Red Rock River drainage				
Corral Creek of Upper Lake			X	
East Fork Clover Creek	X			
Elk Spring Creek of Upper Lake			X	
Hell Roaring Creek of Upper Lake			X	
Jones Creek of Lower Lake	X			
Long Creek				X
*Odell Creek of Lower Lake		X	X	
Peet Creek	X			
Red Rock River, above Upper Lake	X	X	X	
*Red Rock River, lakes to Lima Res.		X	X	X
Red Rock R., Lima to Clark Canyon		X	X	X
Tom Creek of Upper Lake	X		X	

Drainage and Stream	gradient >1%	non-native trout	lake access	degraded habitat
Beaverhead River drainage				
Bear Creek	X			
Beaverhead River, below reservoir		X		
Big Sheep Creek		X		
Black Canyon Creek	X			
Blacktail Deer Creek		X		X
Bloody Dick Creek		X		
Cabin Creek	X			
Deadman Creek		X		
Frying Pan Creek	X			
Grasshopper Creek		X		X
Horse Prairie Creek		X	X	X
Indian Creek	X			
Medicine Lodge Creek		X		X
North Fork Greenhorn Creek	X			
Poindexter Slough		X		
Rape Creek		X	X	
Reservoir Creek	X			
Simpson Creek	X			
Shenon Creek	X			
Trapper Creek	X			

Drainage and Stream	Habitat Deficiencies: gradient >1%	non-native trout	lake access	degraded habitat
Ruby River drainage				
Cottonwood Creek	X	X		
Mill Creek		X		X
**Ruby River above Ruby Reservoir		X	X	
Ruby River below Ruby Reservoir		X		X
Warm Springs Creek		X		X
Wisconsin Creek		X		X
Jefferson River drainage				
Boulder River		X		X
Jefferson River to Three Forks		X		
*Halfway Creek				
Hells Canyon Creek		X		
North Willow Creek	X	X		
South Boulder River	X	X		
South Willow Creek, above Harrison		X	X	X
Whitetail Creek		X		X
Willow Creek		X		
Willow Spring Creek		X		
Madison River drainage				
Antelope Creek above Cliff Lake		X	X	
Beaver Creek above Quake Lake		X	X	X
**Cherry Creek		X		
Cabin Creek	X	X		
**Canyon Creek of Gibbon River		X		
**Cougar Creek				
Darlington Ditch		X		
**Firehole River above Kepler		X		
Firehole River below Kepler		X		
**Gibbon River		X		
*Grayling Creek		X		
Hot Springs Creek		X		
Madison River above Hebgen		X	X	
Madison River below Ennis Reservoir		X		
*South Fork of Madison River		X	X	
Red Canyon Creek		X	X	
Trapper Creek		X		
Watkins Creek above Hebgen	X	X	X	
Gallatin and East Gallatin drainages				
Baker Creek		X		
Ben Hart Spring Creek		X		

Drainage and Stream	Habitat Deficiencies			
	gradient >1%	non-native trout	lake access	degraded habitat
Gallatin and East Gallatin drainages (continued)				
Big Bear Creek	X			
Bridger Creek		X		
East Fork of Hyalite Creek	X		X	
East Gallatin River		X		
*Gallatin River above Taylor Fork		X		
Gallatin River, to Three Forks		X		
Hell Roaring Creek	X	X		
Hyalite Creek, below Reservoir		X		X
Porcupine Creek		X		
Reese Creek		X		
Rey Creek		X		X
Rocky Creek		X		
Sourdough Creek		X		
South Cottonwood Creek	X	X		
South Fork of Hyalite Creek	X		X	
Spanish Creek	X	X		
Squaw Creek	X	X		
Taylor Fork		X		X
Thompson Spring Creek		X		X
West Fork of the Gallatin	X	X		
Missouri River drainage, Canyon Ferry Reservoir to Three Forks				
Avalanch Creek of Canyon Ferry Res.		X	X	
Beaver Creek of Canyon Ferry Res.		X	X	
Confederate Gulch above Canyon F.		X	X	
Crow Creek		X		X
Deep Creek		X	X	
Dry Creek		X		
Duck Creek above Canyon Ferry		X	X	
Missouri River, above Canyon Ferry		X	X	
Sixteen Mile Creek		X		
Trout Creek, above Hauser	X			
Missouri River drainage, Canyon Ferry Reservoir to Great Falls				
Beaver Creek		X	X	
Canyon Creek		X		
Cottonwood Creek of Holter Res.		X	X	
Dearborn River		X		
*Elkhorn Creek				
Flat Creek		X		X
Little Prickly Pear Creek		X		
Lyons Creek		X		

Drainage and Stream	Habitat Deficiencies			
	gradient >1%	non-native trout	lake access	degraded habitat
Missouri River, Canyon Ferry Reservoir to Great Falls (continued)				
McGuire Creek of Hauser Reservoir		X	X	
Middle and S. Forks of Dearborn		X		
Missouri River, Hauser to Holter		X	X	
Missouri River, Holter to G. Falls		X		
Prickley Pear Creek of Lake Helena		X	X	X
Sheep Creek		X		
Silver Creek of Lake Helena		X	X	
Spokane Creek of Hauser Reservoir		X	X	
Stickney Creek		X		
Trout Creek of Hauser Reservoir		X	X	
Virginia Creek		X		
Willow Creek of Holter Reservoir		X	X	
Wegner Creek		X		X
Wolf Creek		X		
Smith River drainage				
Eagle Creek		X		
**Elk Creek of Hound Creek		X		
Hound Creek		X		
*Newlan Creek		X		
North Fork Smith, below Reservoir		X		
North Fork Smith, above Reservoir			X	
Rock Creek		X		
Smith River, to mouth		X		
Sheep Creek		X		
*South Fork of Smith River		X		
Tenderfoot Creek		X		
Sun River drainage				
Elk Creek		X		
North Fork Willow Creek	X			
**North Fork Sun, above Gibson Res.			X	
**South Fork Sun, above Gibson Res.			X	
Sun River, below Diversion Dam		X		
Willow Creek above Gibson Res.		X		

DISCUSSION AND RECOMMENDATIONS

The current state of streams in the native range of grayling in Montana, the upper Missouri River drainage above Great Falls, does not present encouraging prospects for restoration of grayling to native waters. The primary, historic habitat of Montana grayling were the biggest rivers and the lowest reaches of their tributaries, located in the largest, widest, lowest-gradient mountain valleys of the upper Missouri drainage. These rivers are now universally occupied by non-native trout, dams and reservoirs are common, and the lower, low-gradient reaches of many tributaries to these larger streams often suffer from seasonal dewatering.

The most common and serious factor making these larger streams presently unsuitable for grayling is that same factor probably most responsible for their decline and disappearance from these streams - the establishment of non-native brown, rainbow, and brook trout. The sizes of these larger streams and the popularity of their sport fisheries may preclude chemical or other measures to remove these non-native trout. Additionally, one or more of these non-native trout species are established in most other, smaller streams of the upper Missouri River drainage. The only exceptions are a few small, isolated, mountain streams, most of which do not provide good grayling habitat because of their relatively steep gradients. This widespread distribution of non-native trout, from all the larger streams to most of the smaller tributaries, is probably the biggest obstacle to restoration of fluvial Montana grayling within its native range.

Another important obstacle to restoration of fluvial grayling into the larger streams is the tendency of fluvial Arctic grayling to migrate seasonally over extended distances, reported for both Big Hole River and

Alaskan populations. Large dams and reservoirs are present as barriers to migrations on the Madison, Red Rock, Beaverhead, Sun, and Missouri rivers. The only larger rivers within the historic range that are not dammed are the lower Big Hole River below the Divide Dam, the Jefferson, Gallatin, East Gallatin, and Smith rivers, and that part of the Missouri River between Holter Dam and Great Falls. However, as previously discussed, all these streams are inhabited by non-native trout.

On the lower reaches of tributaries, a common additional problem is seasonal dewatering through irrigation withdrawals. Vincent (1962) concluded that such habitat degradation was an important contributing factor to decline and elimination of grayling from some Montana streams. Thus, the lower gradient reaches near the mouths of tributaries, which could provide physical habitat for grayling, either on an extended basis or seasonally as spawning or feeding areas, are rendered unsuitable by a combination of seasonal dewatering (and possible other habitat degradation) and establishment of non-native trout.

Most upper reaches of tributaries are also occupied by non-native trout. Those in which chemical eradication of non-natives is most feasible are small streams above barriers. Such streams above barriers were not occupied by native populations of grayling, but should support grayling if appropriate habitat were available. If Arctic grayling in Montana are glacial relicts existing at marginal temperatures, as is commonly suggested (e.g., Feldmeth and Eriksen 1978), then higher elevation streams would provide cooler, more suitable thermal habitats. In the upper Missouri drainage, however, such streams are most commonly mountain streams with gradients too steep to provide grayling habitat. Restoration of grayling to streams within the native range is thus a much more difficult problem than that of restoring, for example, greenback cutthroat trout to isolated mountain streams in Colorado (U. S. Fish and Wildlife Service 1983).

What remains as potential sites for restoration of fluvial grayling are sections of a few streams, most of them small, which provide low gradient and abundance of pools and are not seasonally dewatered by withdrawals. However, virtually all these streams are also occupied by non-native trout. Chemical eradication of non-native trout does not appear feasible in most of these streams. The more than 60 years of coexistence of small numbers of grayling and brook trout in the upper Big Hole River suggests that, among the non-native trout, brook trout have less impact on grayling than brown or rainbow trout. The streams considered most promising as restoration sites are, therefore, those that have no non-native trout, or have only brook trout, or have rainbow and brown trout only in very low densities.

Most of the few candidate waters are small, short sections of streams. This again invokes the problem of migratory tendency of fluvial grayling, and thereby the very serious and unresolved question of whether there is any realistic hope of establishing grayling in such small streams. It is possible that there may have been fluvial Montana grayling that inhabited smaller streams and did not migrate over extended distances. Vincent (1962) described the now-extirpated grayling of Michigan as being essentially non-migratory fluvial fish. Reports of grayling in such small streams as Bridger and Sourdough creeks (Evermann 1893) near Bozeman support this possibility. However, it is also possible that such reports were based on sightings of fish which had migrated into tributaries from larger rivers, to spawn or to occupy summer habitat. If there were populations in Montana adapted to living permanently within smaller streams and to limited, localized movements within those streams, then such adaptation probably disappeared with those populations.

Wild grayling transplanted from the Big Hole River into Canyon Creek (about 4 to 7.5 cfs), and from the Sunny Slope Canal into Rock Creek (roughly 25 cfs, Hill, pers. comm.), have shown little inclination to remain in smaller streams. Similarly, hatchery-reared, juvenile Big Hole River grayling recently planted into the upper Gallatin River appear to have moved downstream into the larger, low gradient reaches with large pools. There, the presence of brown and rainbow trout will likely prevent their establishment as a fluvial grayling population.

A possible solution to this apparent dilemma of migratory tendency and apparent unsuitability of small streams would be to try and re-create, via natural selection in the field, populations adapted to living in small streams. This could be attempted through repeated introductions, over a period of years, of large numbers of fluvial grayling into streams with suitable habitat located above a one-way barrier. The barriers would act as a selective force, isolating those that were behaviorally inclined to remain within the stream while removing from the potential gene pool those that moved downstream. Even if only small proportions of planted fish remained upstream, continued stocking with large numbers may isolate enough individuals to begin a resident, reproducing population. Repeated stockings with large numbers of fluvial grayling could have other benefits. One would be to reduce the possible loss of genetic diversity in a small, new population, a possibility which would be aggravated if the new population originated from a few survivors of a single planting. Repeated stockings with large numbers may also partially compensate for negative effects of the non-native trout in the candidate streams. If the survival of planted grayling or their tendency to remain within a stream section were reduced through negative interactions with established non-native trout, then perhaps repeated stockings with large numbers of grayling could still produce enough remaining fish to start a new population. Continued selection by the barrier of any resulting progeny could perhaps eventually produce a population adapted to maintaining itself in a small stream. A similar mechanism may have produced the population of grayling residing in Sunny Slope Canal, with Pishkun Reservoir serving as the source of repeated introductions into the canal, and the drop structures acting as a selective force on the introduced grayling and their progeny.

Past efforts with Big Hole River or Sunny Slope Canal grayling have involved only single transplants of relatively few fish. The 1976 transplant of Big Hole River grayling into Canyon Creek (tributary of the Gibbon River) involved only about 120 fish. The 1983 effort on Rock Creek (tributary of the North Fork Sun River) was a single transplant of about 400 grayling from Sunny Slope Canal. Recent progress with egg-taking from Big Hole River fish, creation of Axolotl Lake and hatchery brood stocks, and advances in hatchery culture of grayling, have demonstrated that future stocking programs can have continuing access to thousands of juvenile, hatchery-reared fluvial grayling.

Candidate streams for such attempts could include the upper Gibbon River in sections above Virginia Cascades, Canyon Creek, the upper Firehole River above Kepler Cascades, and the Butler Reach of Cherry Creek, all of the Madison River drainage. The Firehole River, Gibbon River, and Canyon Creek are within Yellowstone National Park. All are above existing barriers, and are reasonably accessible for planting fish and monitoring their status. The upper Firehole River, upper Gibbon River, and the Butler Reach of Cherry Creek are especially accessible, via paved, service, or ranch roads which parallel much of the reaches suggested. For Canyon Creek, the brown trout which dominate its community should be eradicated and the functioning of the artificial barrier should be confirmed. For the upper Firehole and upper Gibbon rivers, chemical eradication of their predominantly brook trout populations may not be feasible. If these streams cannot be chemically rehabilitated, then it would probably be especially important to repeatedly plant large numbers of juvenile fluvial grayling. For the Butler section of Cherry Creek, negotiations would need to be conducted with the land owner for possible chemical removal of non-natives and introduction of a native combination of fluvial grayling and westslope cutthroat trout.

Another candidate stream in this first category would be Elk Creek, tributary of Hound Creek of the Smith River drainage. Although similar to Canyon Creek in size, general characteristics and apparent high biological productivity, it differs in having rainbow instead of brown trout as the predominant non-native, and in lacking a barrier to the main stream (Hound Creek). If construction of a barrier is feasible, then this stream could also be a candidate for attempting to create a small-stream population through repeated plants of large numbers of fish. Without a barrier, however, it is unlikely that grayling would establish a population in this short section of a small tributary of a larger stream inhabited by brown and rainbow trout. This is the only stream identified by this survey as a potential site for restoration efforts in the Smith River drainage.

Another possible approach to creating a population adapted to a small stream would be to plant fluvial grayling into a stream from which they cannot leave. Again, repeated stockings of fish should be made to try and produce enough survivors to start a population. If some fish did survive and reproduce, then continued natural selection of their progeny could eventually produce a population adapted to living in a small stream. The candidate stream for such an attempt would be Cougar Creek, another tributary of the Madison River within Yellowstone National Park. Cougar Creek would provide up to about five miles of low gradient, small stream, before its surface flow ceases through seepage into the ground. Only westslope cutthroat trout and mottled sculpins, both indigenous to the Madison River drainage, presently inhabit this stream. Access to the stream is not convenient, since the nearest point is about 3.5 miles by trail from the closest road. However, the trail has relatively low gradient and would not present a serious obstacle to monitoring the status of planted fish.

There appears to be very little potential for restoration of fluvial Montana grayling into a stream within its native range that would be large enough to provide the opportunity for extended migrations. The best possibility may be the Ruby River between its headwaters and Ruby Reservoir. However, this river also shares certain disadvantages with the other larger streams, and chances of success are therefore questionable. In addition to the presence of the reservoir, the Ruby River also is inhabited by brown, rainbow and brook trout. However, as previously described, the upper half of the river reach above the reservoir has certain similarities to the Big Hole River. These include relatively low numbers of non-native trout, with brown trout being relatively uncommon, the presence of about 20 miles of low-gradient stream with many large pools, and tributaries with low gradient sections near their mouths. A graded road provides access to this upper half of the river, and would facilitate planting fish and monitoring their subsequent status.

Without a barrier to upstream migration from the reservoir, it would be questionable whether a completely fluvial population of grayling could be established on the upper Ruby River. Sites for constructing a barrier are probably present in canyon reaches which begin about 20 river miles above the reservoir. Such a barrier would prevent grayling from migrating back and forth between the stream and reservoir, while still retaining access to miles of stream for spawning by reservoir trout. The barrier would also separate the lower sections closer to the reservoir, which contain more brown trout, from the approximately 20 miles of stream above where brown trout are much less common.

Because of the length and volume of stream involved, an effort to establish fluvial grayling in the upper Ruby River would require much greater effort and expense than attempts in the smaller streams described previously. However, among the streams of the upper Missouri drainage, this appears to provide the best possibility for establishing fluvial grayling in a physical setting with similarities to the Big Hole River. Estimated total number of trout per mile on the Ruby River, even in the uppermost, three forks area, is similar to or greater than estimated total number of trout and grayling on the Wisdom section of the Big Hole River. This suggests that if grayling were to be established in the upper Ruby River, their density could be similar to or higher than within the Wisdom section of the Big Hole River, where grayling are most common.

The North and South Forks of the Sun River may also provide sites for establishment of fluvial grayling in larger streams. They both share with other streams the disadvantage of having non-native trout (rainbow and brook trout). The North Fork has the further disadvantage of unimpeded access between Gibson Reservoir and the stream, while there is a low barrier in the lower reaches of the South Fork (Bill Hill, pers. comm.). Because of their relatively remote locations and the little background information available, we have little basis for assessing their suitability. This remoteness would also make it difficult to plant large numbers of juveniles, or to monitor their status, or to construct barriers. These considerations appear to reduce their attractiveness as sites for grayling restoration. However, on-site surveys of both physical and biological characteristics of these streams are required to further assess their potentials as restoration sites.

A relatively simple introduction of grayling would be into Cougar Creek. Since this is a completely isolated stream with only native, westslope cutthroat trout and sculpins present, restoration efforts would consist simply of repeated plants of young Big Hole River grayling. Such grayling are already available at the U. S. Fish Technology Center (U. S. Fish and Wildlife Service) in Bozeman. For these reasons, Cougar Creek appears to be suitable for early restoration efforts, even though the creek could probably sustain relatively few, small grayling.

Other sites would require greater expenditures and effort, associated with rearing large numbers of young grayling after obtaining gametes from wild or captive stocks, chemical or physical reduction of established non-native trout, and for a number of potential sites, construction of barriers to upstream movements of fish. With such practical considerations in mind, I would suggest the following order of priority after Cougar Creek, in an approximately escalating sequence of probable effort and expense. (1) Upper Firehole River, with grayling introduced on top of the present, low densities of brook trout and smaller numbers of brown trout. I assume that it would be difficult to obtain permission to introduce fish toxicant into a stream which provides drinking water to a large visitor complex. (2) Virginia Meadows of the Gibbon, after an initial treatment, either chemical or physical (electrofishing runs) to reduce the dense population of brook trout (and a few rainbow trout). Such reduction would be facilitated by the short stream section involved, only about 1.6 miles, and its relatively small discharge volume. (3) Butler Reach of Cherry Creek, after chemical treatment to substantially reduce present high densities of rainbow and brook trout. This assumes that landowner permission to do so can be negotiated. Physical removal of non-native trout could also be considered, but would be made more difficult by the presence of many large, deep pools. (4) Canyon Creek, after intensive effort to eradicate all non-natives, especially brown trout. Canyon Creek is probably not a suitable site if such eradication, attempted unsuccessfully in 1975, is not considered feasible. (5) Elk Creek, after construction of a barrier near its confluence with Hound Creek and after treatment, either physical or chemical, to reduce numbers of rainbow and brook trout. Elk Creek is probably not a suitable site without construction of a barrier. (6) Upper Ruby River, after construction of a barrier above the reservoir. Because of its size and length, this site would require large numbers of fish for stockings. Grayling could be stocked on top of existing, relatively low densities of rainbow and brook trout. If effort and expense are not foremost considerations, then the upper Ruby River should receive higher priority. (7) South Fork of the Sun River, with grayling planted on top of present, assumed low densities of non-native rainbow, cutthroat, and brook trout, upstream from the low barrier above Gibson Reservoir. (8) North

Fork of the Sun River, after construction (if site can be located) of barrier from Gibson Reservoir, with grayling planted on top of existing, presumably low densities of non-native rainbow, cutthroat, and brook trout.

Another aspect of restoration of fluvial grayling should involve the Big Hole River itself (Fig. 11). The uppermost reaches of the river, from near the town of Jackson to headwater reaches at Skinner Meadows, appear to fulfill the criteria for grayling habitat as well as or better than any of the streams presented as potential sites for restoration efforts. I examined this part of the Big Hole River in July, 1992. This is a long (about 25 miles), low gradient (average of about 0.7%), stretch of river with many pools, with relatively large volume (mean annual flow of 47 cfs near Jackson, Parrett et al. 1989), with macrophyte beds common, and with apparent good biological productivity. There are miles of stream with gradient considerably less than the 0.7% average. Upper reaches are above most or all irrigation diversions. The only obvious, major detraction is an abundance of brook trout, a characteristic shared with some of the candidate streams for grayling reintroductions. Brook trout were obviously abundant and readily visibile in many pools and deep runs in this part of the river. Except for beaver dams, there are no barriers to movement of graylng between these upper reaches and sections below, near the town of Wisdom, where grayling are most common.

Given these characteristics of the upper Big Hole River above Jackson, the possibility of expanding the distribution of grayling into these waters appears as good or better than the possibility of establishing grayling in the other candidate streams mentioned in this report. The absence of grayling may be due to the abundance of brook trout. Heaton (1960) captured 165 brook trout (and no grayling) in a 300-ft section of the river

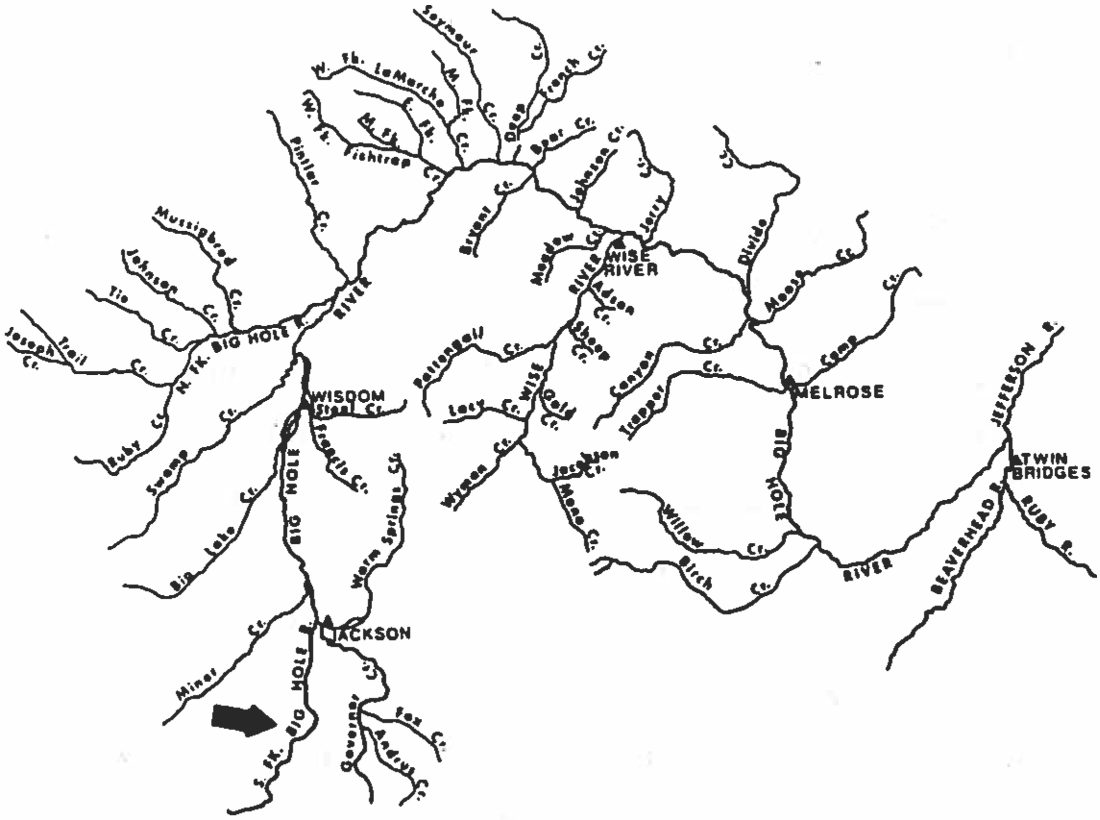


Figure 11. Big Hole River and tributaries (from MDFWP 1989a). Discussed as a potential grayling restoration site is about 25 miles of stream above the confluence with Governor Creek near Jackson. This part of the river is also known as the South Fork of the Big Hole River.

at Skinner Meadows, compared to only 8 brook trout (and 1 grayling) in a 300-ft section at Swamp Creek Road, the latter within the area in which grayling are presently most common. A 1980 survey by MDFWP (1989a) of a 1,300 ft section within these upper reaches of the upper Big Hole River yielded an estimate of 443 brook trout over 5 inches in length per 1000 ft (2,339 per mile) and few rainbow trout. It would probably not be feasible to attempt to chemically eradicate brook trout from the upper Big Hole River, because of its size and its many tributaries, branches, and backwaters inhabited by trout. It may be worthwhile, however, to attempt the approach suggested previously for the smaller streams, and repeatedly plant large numbers of juvenile Big Hole River grayling into these upper reaches. Again, the approach would be to plant many grayling, repeatedly, amidst the existing brook trout and thereby try to produce a sufficient pool of grayling which remained in place and survived to start a locally adapted subpopulation. This part of the Big Hole River supports much higher densities of salmonids (brook trout), than those sections downstream currently occupied by grayling. If even a small percentage of this dense brook trout population were to be translated into grayling, this would substantially increase the total number of grayling in the Big Hole River. Efforts to promote upstream expansion of grayling into these reaches should, therefore, have a high priority.

Downstream near the Divide Dam, at the end of the Wisdom-Divide "grayling stretch" of the Big Hole River, attempts should be made to enhance the status of resident fluvial grayling by reducing non-native trout. The section between the Dickie Bridge and Divide Dam is currently managed with policies that appear contrary to such an objective. In this section, the presence of large trout is encouraged by current fishing regulations (4 trout limit, 3 under 13 inches and only one over 22 inches). These regulations may exacerbate negative effects of trout on river grayling, by increasing the opportunity for survival of larger trout between 13 and 22 inches. Such fish would be of prime spawning size and thereby function to maximize densities of trout, increasing the likelihood of negative effects on river grayling. The regulations also serve to protect and enhance brown trout, which may be the species with the greatest negative impact on fluvial grayling. The sport fishery for brown trout in these waters appears to be a recent development. Wipperman (1965) reported that "brown trout do not inhabit that portion of the river above Divide Dam because the dam is a barrier to upstream movement of fish." Protection and enhancement of brown trout in this part of the Big Hole River, above the Divide Dam, not only is detrimental to enhancement of grayling in this section, but also increases the possibility of eventual upstream colonization from a large, resident pool of brown trout. The regulations should be changed to maximize removal of all trout above the Divide Dam, and other measures such as removal by electrofishing should also be considered. Given the low population densities and limited distribution of fluvial grayling within the Big Hole River, any increase in numbers of grayling in this section of the river near Divide would be a significant contribution to the status of this population. Enhancement of grayling in this part of the river would involve a change in regulations, rather than stocking of fish, and should be given highest priority.

Another aspect of fluvial grayling restoration, not included in this survey of potential sites, is the status of the Madison River/Ennis Reservoir population. Most grayling in this system appear to be adfluvial, inhabiting the reservoir and ascending the river during spring to spawn.

However, some are found in the Madison River upstream from the reservoir throughout the summer and into at least early fall, well beyond the spawning season (Vincent pers. comm., Byorth and Shepard 1990). The entire Madison River/Ennis Reservoir population is small, roughly estimated in 1990 at about 545 fish longer than 10 inches (Byorth and Shepard 1990). However, the population appears to have been increasing in recent years, as indicated by increasing numbers of spawners (Byorth, pers. comm.). The Madison River is native habitat for fluvial grayling, and Ennis Reservoir fills an area once partially occupied by a small, shallow lake. Studies are currently underway by biologists from MDFWP and the Montana Power Company to better define the behavior and life history of this population. Confirmation of fluvial characteristics of this population would justify their inclusion into restoration goals for fluvial Montana grayling.

The role of the population in the Sunny Slope Canal, an artificial tributary of the Sun River, also needs to be clarified with respect to the present status of fluvial Montana grayling and future restoration efforts. As described previously, these fish live in an artificial riverine habitat for about five months of the year and in isolated pools for about the remaining seven months. The latter period of residence in non-flowing water means that they do not spend their entire lives in a riverine habitat. However, the small, isolated pools in which they overwinter do not seem reasonably equivalent to lakes or reservoirs and therefore, it would not seem appropriate to consider this to be an adfluvial population. Rather, it would seem more appropriate to consider these to be fluvial fish that are left stranded in pools when their artificial, riverine habitat is seasonally dewatered. This population may possess, as a result of selective forces in this unusual environment, adaptive characteristics advantageous to future attempts to restore grayling to streams. These may include the ability, including among the very young, to persist in flowing water and the ability to survive severe dewatering in isolated pools and runs. They are now protected by catch-and-release regulations, and this protection should continue.

One aspect that needs to be substantiated is reproduction, and therefore self-perpetuation of this population, entirely within the canal. This is presently assumed, given the apparent absence or extreme scarcity of grayling in Pishkun Reservoir. Their reproduction within the canal should be confirmed through a study on spawning behavior and locations within the canal, and distribution and behavior of young-of-year produced. If it can be confirmed that this population is maintaining itself through reproduction within the canal, then it would seem appropriate to consider this to be an additional fluvial population, although one aberrant genetically (Everett and Allendorf 1985) and in its physical habitat.

SUMMARY

The primary, indigenous habitat of Montana grayling - the largest, low gradient streams in broad valleys of the upper Missouri drainage above Great Falls - appear to be no longer suitable for restoration of these fish. The factors which likely led to their disappearance from these streams, including establishment of non-native trout, construction of dams and reservoirs, and dewatering of lower reaches of tributaries, remain effective as substantial obstacles to restoration of grayling into the same waters. Among the streams suggested as potential sites for restoration by this survey, only one or two- the upper Big Hole River, and possibly the upper Ruby River - are waters in which grayling were probably found as native inhabitants. Most of the others are streams above barriers and did

not contain native grayling populations. All but one of these candidate streams contain non-native trout, predominantly brook trout or rainbow trout. These species, at least when present at low densities, are thought to have less negative effects on grayling than do brown trout. Both species are present in low densities and coexist with grayling in sections of the Big Hole River near Wisdom, where the remaining fluvial Montana grayling are most common.

Locations and drainages within the upper Missouri River basin of the sites proposed for potential restoration efforts are summarized in Figure 12. Two of these proposed sites, the upper Big Hole River above Jackson and the upper Ruby River above Ruby Reservoir, are moderate-sized stream sections with mean discharge volumes about 50 to 100 cfs and low gradient reaches of about 20 to 25 miles. Such habitat dimensions may give these sites the potential to support densities and total numbers of grayling similar to or exceeding that of the present, depressed fluvial grayling population of the Big Hole River. Both have obstacles to restoration of grayling. The Big Hole river above Jackson has an abundance of brook trout. The Ruby River has rainbow trout in relatively low densities plus a few brown trout. There is no barrier between these upper reaches and both Ruby Reservoir and the lower reaches near the reservoir, which support higher numbers of brown trout. Construction of a drop-barrier on the upper Ruby River would probably enhance, and perhaps be necessary for, establishment of grayling. On the Big Hole River above Jackson, grayling are absent or scarce despite the apparently favorable physical habitat and unimpeded access from reaches below, near Wisdom, where they are most numerous. This seems related to the high densities of brook trout. It would not be possible to eradicate the large numbers of brook trout present

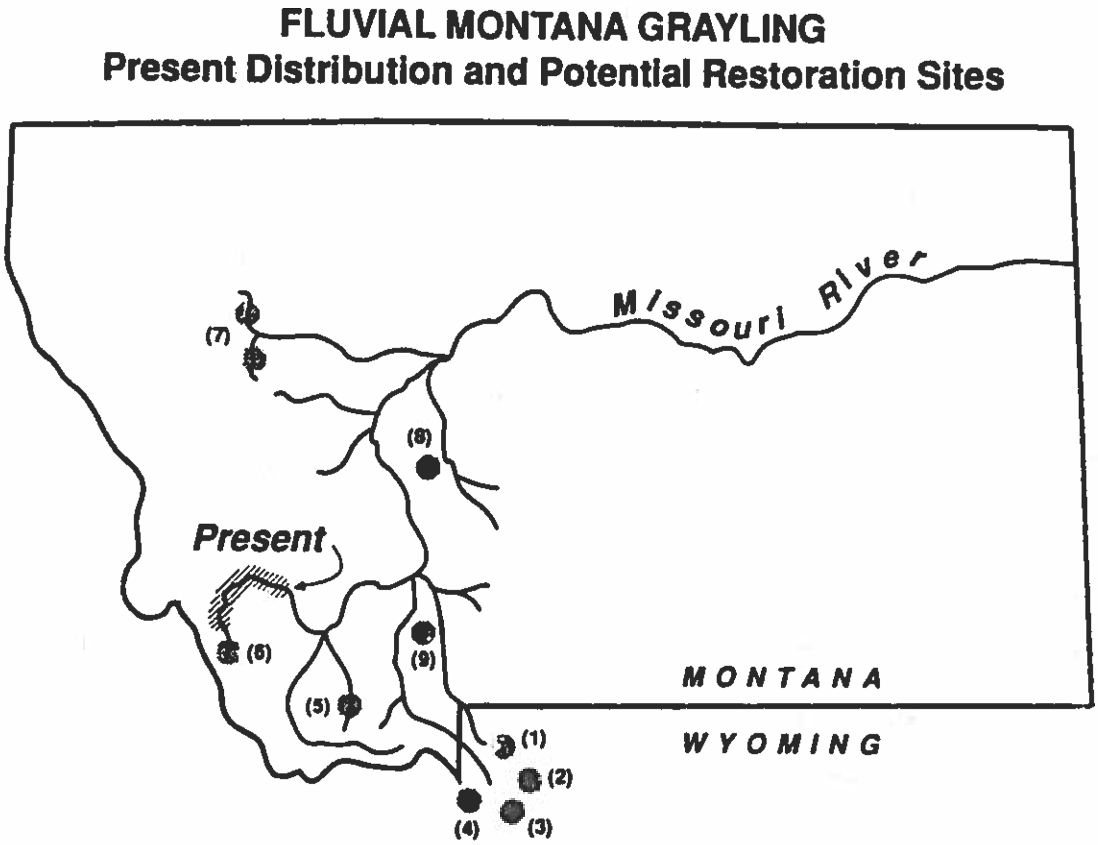


Figure 12. Present distribution of fluvial Arctic grayling in the upper Big Hole River, and potential restoration sites within the native range of the Missouri River basin above Great Falls. (1) Cougar Creek, (2) Virginia Meadows reach of the Gibbon River, (3) Canyon Creek, tributary of the Gibbon River, (4) Firehole River above Kepler Cascades, (5) upper Ruby River above Ruby Reservoir, (6) Big Hole River above Jackson, (7) North Fork and South Fork of the Sun River, (8) Elk Creek, tributary of Hound Creek of the Smith River, (9) Butler Reach of Cherry Creek, tributary of the Madison River. Not indicated on the map are the populations of Madison River/Ennis Reservoir, and the Sunny Slope Canal, both discussed in this report.

in the river and numerous tributaries. However, it would be desireable to reduce their high densities before grayling are introduced.

The Butler Reach of Cherry Creek, tributary to the lower Madison River, may also have the potential to support a population of grayling that may approach the current, depressed numbers found in the Big Hole River. Although relatively small with a base flow that may be about 20-25 cfs, it is apparently very high in productivity of trout and supports high population densities of rainbow and brook trout. The landowner does appear receptive to the concept of replacing these non-native trout with a native community of westslope cutthroat trout and grayling. However, chemical reduction of the current high densities of non-native trout would probably have to be negotiated with the landowner to improve the prospects of establishing grayling in this stream.

Five other sites proposed, Virginia Meadows on the upper Gibbon River, Cougar Creek, Canyon Creek, and the upper Firehole River - all in the upper Madison River drainage - and Elk Creek within the Smith River drainage, can potentially support small populations of grayling, of perhaps several hundred or more age-1+ fish in each. Production of grayling would be limited by small flows of less than 10 cfs (Cougar Creek Canyon Creek and Elk Creek), or short stream length available (Virginia Meadows on the upper Gibbon River), or low stream productivity (upper Firehole River). Most have additional disadvantages, including presence of non-native trout (all except Cougar Creek). These streams are small enough for chemical reduction of non-native trout, but such treatment may be prevented by social or administrative considerations. Of these streams, only Canyon Creek has a predominance of brown trout. Unless the stream could be treated to remove these brown trout, as was attempted unsuccessfully in

1975, Canyon Creek probably should not be considered as a grayling restoration site. All have barriers separating the stream sections from upstream movements of trout, except Elk Creek. Elk Creek probably should not be a considered unless a barrier can be built near its confluence with Hound Creek.

Two other streams, the North and South Forks of the Sun River above Gison Reservoir, have potential for grayling restoration which are largely unknown at this time. Their inclusion as possible sites is based largely on their relatively long reaches of about 12 miles (South Fork) to 21 miles (North Fork) of low gradient stream, large base flows near 100 cfs, and absence of brown trout. The North Fork appears to offer better habitat with lower gradient and more pools (Hill, pers. comm.), but does not have any barrier from Gibson Reservoir. The South Fork does have a small barrier upstream from the reservoir. Both are relatively remote with difficult access for planting or monitoring of fish. Further evaluation of either tributary would require ground survey of their physical configurations, especially presence of pools, and for the North Fork, whether a suitable site exists for construction of a barrier.

Other aspects of fluvial grayling restoration should be pursued. The present regulations designed to protect and increase large rainbow and brown trout in the Divide to Dickie Bridge section of the Big Hole River may be detrimental to grayling. The emphasis should be reversed, toward severe reduction of brown and rainbow trout of all sizes in the entire Big Hole River above Divide. Present studies to elucidate the life histories of Madison River/Ennis Reservoir grayling should be continued. This is an important, probably native, population which may be in the process of re-expanding its range upstream into further reaches of the Madison River.

Confirmation of fluvial life histories of a portion of the population would warrant their inclusion into restoration goals. Finally, the life histories of Sunny Slope Canal grayling should be investigated, particularly with respect to spawning and to behavior and distribution of young. If in-stream reproduction can be confirmed, then it would seem appropriate to regard this population as being fluvial despite their unusual habitat, and would justify including these fish in conservation planning for grayling restoration goals.

None of the streams proposed as potential restoration sites was among the more important indigenous habitats for grayling, and each has limitations which detract from providing the most suitable conditions for supporting a self-sustaining grayling population. The likelihood of successful establishment of a self-sustaining population may not be high in any of these streams. Despite such uncertain probability of success, restoration efforts are necessitated by the depressed status of the Big Hole River population. Establishment of any additional populations would represent a substantial improvement in the status of fluvial grayling in Montana.

LITERATURE CITED, AND OTHER INFORMATION SOURCES

Armstrong, R. H. 1986. A review of Arctic grayling studies in Alaska, 1952-1982. Biological Papers of the University of Alaska, No. 23. University of Alaska, Fairbanks.

Benson, N. G., O. B. Cope, and R. V. Bulkley. 1959. Fishery management studies on the Madison River system in Yellowstone National Park. U.S. Department of the Interior, Fish and Wildlife Service, Special Scientific Report - Fisheries No. 307.

Brown, C. J. D. 1938. Observations of the life-history and breeding habits of the Montana grayling. Copeia 1938:12-19.

Byorth, P. A. 1992. Big Hole River Arctic grayling recovery project. Quarterly Report for the period July through September, 1992. Montana Department of Fish, Wildlife and Parks, Helena.

Byorth, P. A. and B. B. Shepard. 1990. Ennis Reservoir/Madison River fisheries investigation, Draft Final Report: 1990.

Byorth, P.A. 1991. Population surveys and analysis of fall and winter movements of Arctic grayling in the Big Hole River: 1991 Final Report. Submitted to: Fluvial Arctic Grayling Workgroup, Grayling Restoration Technical Advisory Committee; Beaverhead National Forest; U.S. Bureau of Land Management; U.S. Fish and Wildlife Service; Montana Department of Fish, Wildlife and Parks; Montana Council, Trout Unlimited.

Burkhalter, D. B. Thermal and hydraulic characteristics of the Firehole River in Yellowstone Park. Ph.D. Thesis, Montana State University, Bozeman.

Decker-Hess, J. 1989. An inventory of the spring creeks in Montana. Prepared for: The American Fisheries Society, Bethesda, Maryland.

Dean, J. L. and L. E. Mills. 1971. Annual project report for 1970. Fishery Management Program. Yellowstone National Park, Mammoth, Wyoming.

Dean, J. L. and J. D. Varley. 1974. Annual project report for 1973. Fishery Management Program. Yellowstone National Park, Mammoth, Wyoming.

Deleray, M. 1991. Movement and utilization of fluvial habitat by age-0 Arctic grayling, and characteristics of spawning adults, in the outlet of Deer Lake, Gallatin County, Montana. M.S. Thesis. Montana State University, Bozeman.

Elrod, M. J. 1931. History of the Montana grayling. Montana Wildlife 3:10-12.

Evermann, B. W. 1893. A reconnaissance of the streams and lakes of western Montana and northwestern Wyoming. Bulletin of the United States Fish Commission 9:3-60.

Everett, R. J. and F. W. Allendorf. 1985. Population genetics of Arctic grayling: Grebe Lake, Yellowstone National Park. Genetics Laboratory Report 85/1, Zoology Department, University of Montana, Missoula.

Feldmeth, C. R. and C. H. Eriksen. 1978. A hypothesis to explain the distribution of native trout in a drainage of Montana's Big Hole River. Internationale Vereinigung fur Theoretische and Angewandte Limnologie Verhandlungen 19:2448-2455.

Fuqua, C. L. 1929. Restocking the famous Madison. Montana Wildlife 10:10-12.

Genter, D. L. 1992. Animal species of special concern in Montana. Montana Natural Heritage Program, Helena.

Heaton, J.R. 1960. Southwestern Montana fishery study. Inventory of the project area-Big Hole River drainage survey. Project F-9-R-8, Job No. I. Montana Department of Fish, Wildlife and Parks, Helena.

Heggenes, J. and T. Traaen. 1988. Downstream migration and critical water velocities in stream channels for fry of four salmonid species. Journal of Fish Biology 32:717-727.

Hubert, W. A., R. S. Helzner, L. A. Lee, and P. C. Nelson. 1985. Habitat suitability index models and instream flow suitability curves: Arctic grayling riverine populations. Biological Report 82(10.110), U.S. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C.

Inter-Fluve, Inc. Fisheries report for Sixteenmile Creek, Spanish Creek, and Cherry Creek on the Turner properties, Gallatin and Madison Counties, Montana. Prepared for: Ted Turner, One CNN Center, Atlanta, Georgia.

Jones, R. D., J. D. Varley, D. E. Jennings, S. M. Rubrecht, R. E. Greswell. 1977. Annual project technical report - 1976. Fishery and aquatic management program. Yellowstone National Park, Mammoth, Wyoming.

Jones, R. D., J. D. Varley, R. G. Gresswell, D. E. Jennings, S. M. Rubrecht. 1978. Annual project technical report - 1977. Fishery and aquatic management program. Yellowstone National Park, Mammoth, Wyoming.

Jones, R. D., P. E. Bigelow, D. Carty, R. E. Gresswell, and S. M. Rubrecht. 1981. Annual project technical report for 1980. Fishery and aquatic management program. Yellowstone National Park, Mammoth, Wyoming.

Jones, R. D., P. E. Bigelow, L. D. Lentsch, and R. A. Valdez. 1983. Annual project technical report for 1982. Fishery and aquatic management program. Yellowstone National Park, Mammoth, Wyoming.

Jones, R. D., R. Andrascik, D. G. Carty, R. Ewing, L. R. Kaeding, B. M. Kelly, D. L. Mahony, T. Olliff. 1991. Annual Project Technical Report for 1990. Fishery and aquatic management program. Yellowstone National Park, Mammoth, Wyoming.

Jones, R. D., R. Andrascik, D. G. Carty, L. R. Kaeding, B. M. Kelly, D. L. Mahony, T. Olliff. 1992. Annual project technical report for 1991. Fishery and aquatic management program. Yellowstone National Park, Mammoth, Wyoming.

Jordan, D. S. 1891. A reconnoissance of the streams and lakes of the Yellowstone National Park, Wyoming, in the interest of the United States Fish Commission. Bulletin of the United States Fish Commission 9:41-63.

Kaeding, L. R. 1980. Observations on communities of brook and brown trout separated by an upstream-movement barrier on the Firehole River. The Progressive Fish-Culturist 42:174-176.

Kaeding, L. R. and C. M. Kaya. 1978. Growth and diets of trout from contrasting environments in a geothermally heated stream: the Firehole River of Yellowstone National Park. Transactions of the American Fisheries Society 107:432-438.

Kaya, C. M. 1990. Status report on fluvial Arctic grayling (Thymallus arcticus) in Montana. Prepared for: Montana Department of Fish, Wildife and Parks, Helena.

Kaya, C. M. 1991. Rheotactic differentiation between fluvial and lacustrine populations of Arctic grayling (Thymallus arcticus), and implications for the only remaining indigenous population of fluvial "Montana grayling." Canadian Journal of Fisheries and Aquatic Sciences 48:53-59.

Kaya, C. M. 1992. Decline and status of fluvial Arctic grayling in Montana. Proceedings of the Montana Academy of Sciences (in press).

Kaya, C. M. and L. R. Kaeding. 1979. Effects of geothermal effluents on the fishery of the Firehole River, Yellowstone National Park. Proceedings of the 2nd Conference on Scientific Research in the National Parks. American Institute of Biological Sciences and National Parks Service 2:132-140.

Kelly, J. L. 1931. Nation watches Montana grayling. Montana Wildlife 3:9-11.

Lee, K. M. 1985. Resource partitioning and behavioral interactions among young-of-the-year salmonids, Chena River, Alaska. M.S. Thesis. University of Alaska, Fairbanks.

Liknes, G. A. 1981. The fluvial Arctic grayling (Thymallus arcticus of the upper Big Hole River drainage, Montana. M.S. Thesis. Montana State University, Bozeman.

Liknes, G. A. and W. R. Gould. 1987. The distribution, habitat and population characteristics of fluvial Arctic grayling (Thymallus arcticus) in Montana. Northwest Science 61:122-129.

Lund, J. A. 1974. The reproduction of salmonids in the inlets of Elk Lake, Montana. M.S. Thesis. Montana State University, Bozeman.

Lynch, J. D. and E. R. Vyse. 1979. Genetic variability and divergence in grayling, Thymallus arcticus. Genetics 92:263-278.

McClure, W. V. and W. R. Gould. 1991. Response of underyearling fluvial Arctic grayling (Thymallus arcticus) to velocity, depth, and overhead cover in artificial enclosures. Northwest Science 65:201-204.

McMichael, G. A. 1990. Distribution, relative abundance, and habitat utilization of the Arctic grayling (Thymallus arcticus) in the upper Big Hole River drainage, Montana, June 24 to August 28, 1989. Report to: Montana Department of Fish, Wildlife and Parks; Montana Natural Heritage Program; Beaverhead National Forest; Montana Cooperative Fishery Research Program.

Montana Department of Fish, Wildlife and Parks. 1989a. Application for reservations of water in the Missouri River Above Fort Peck Dam. Vol. 2. Reservation requests for waters above Canyon Ferry Dam. Submitted to: Montana Board of Natural Resources and Conservation, Helena.

Montana Department of Fish, Wildlife and Parks. 1989b. Application for reservations of water in the Missouri River above Fort Peck Dam. Vol. 3. Reservations Requests for waters between Canyon Ferry Dam and Fort Peck Dam. Submitted to: Montana Board of Natural Resources and Conservation, Helena.

Montana Department of Fish, Wildlife and Parks. 1981. Instream flow evaluation for selected waterways of the Beaverhead, Big Hole and Red Rock River drainages of Southwest Montana. Prepared for: U.S. Department of the Interior, Bureau of Land Management, Billings, Montana.

Montana Fish Planting Reports. (Montana Department of Fish, Wildlife and Parks, computer database).

Montana Interagency Stream Fishery Data. (Montana Department of Fish, Wildlife and Parks, computer database).

Nelson, P. H. 1954. LIfe history and management of the American grayling (Thymallus signifer tricolor) in Montana. Journal of Wildlife Management 18:324-342.

Northcote, T. G. 1962. Migratory behavior of juvenile rainbow trout, Salmo gairdneri, in outlet and inlet streams of Loon Lake, British Columbia. Journal of the Fisheries Research Board of Canada 19:201-270.

Parrett, C., D. R. Johnson, and J. A. Hull. 1989. Estimates of monthly streamflow characteristics at selected sites in the upper Missouri River basin, Montana, base period water years 1937-86. U.S. Geological Survey, Water-Resources Investigations Report 89-4082.

Peterman, L. J. 1972. The biology and population characteristics of the Arctic grayling in Lake Agnes, Montana. M.S. Thesis. Montana State University, Bozeman.

Reynolds, J. B. 1989. Evaluation of the HSI model for riverine Arctic grayling in relation to Alaskan project impacts. Unit Contribution no. 32, Alaska Cooperative Fishery Research Unit, University of Alaska, Fairbanks.

Seamans, J. E. 1940. A report on a survey of some of the trout streams of Yellowstone National Park. National Park Service, unpublished report.

Shepard, B. B. and R. A. Oswald. 1989. Timing, location and population characteristics of spawning Montana grayling (Thymallus arcticus montanus [Milner]) in the Big Hole River drainage, 1988. Report submitted to: Montana Department of Fish, Wildlife and Parks; Montana Natural Heritage Program - Nature Conservancy; U.S. Forest Service, Northern Region.

Skaar, D. 1989. Distribution, relative abundance and habitat utilization of the Arctic grayling (Thymallus arcticus) in the upper Big Hole River drainage, Montana, July 5 to September 8, 1988. Report to: Montana Department of Fish, Wildlife and Parks; Montana Natural Heritage Program; Beaverhead National Forest; Montana Cooperative Fishery Research Unit.

Streu, J. M. 1990. Select aspects of the life history and ecology of the Montana Arctic grayling (Thymallus arcticus montanus) [Milner] in the upper Big Hole River drainage, Montana. Montana Department of Fish, Wildlife and Parks; Montana Natural Heritage Program; Beaverhead National Forest; Montana Cooperative Fishery Research Unit.

Tyron, C. A. 1947. The Montana grayling. The Progressive Fish-Culturist 9:136-142.

U. S. and Wildlife Service. 1983. Greenback Cutthroat Trout Plan. Prepared by the Greenbck Cutthroat Trout Recovery Team. USFWS, Denver, Colorado.

U. S. Geological Survey. 1991. Water Resources Data, Montana, Water Year 1990. U. S. Geological Survey, Helena, Montana.

U. S. Geological Survey. (various dates, area quadrangle maps, 1:24,000 scale). U. S. Geological Survey, Washington, D.C.

Varley, J. D. 1981. A history of fish stocking in Yellowstone National Park between 1881 and 1980. Information Paper No. 35, Yellowstone National Park, Mammoth, Wyoming.

Vincent, Richard E., W. Fredenberg, R. Oswald, and B. Shepard. 1990. Statewide fisheries investigations. Survey and inventory of cold water streams. Southwest Montana cold water stream investigations. Project No. F-46-R-3, Job No. I-e.

Vincent, Richard E. 1967. A comparison of riffle insect populations in the Gibbon River above and below the geyser basins, Yellowstone National Park. Limnology and Oceanography 12:18-26.

Vincent, Robert E. 1962. Biogeographical and ecological factors contributing to the decline of Arctic grayling, Thymallus arcticus Pallas, in Michigan and Montana. Ph.D. Thesis. University of Michigan, Ann Arbor.

Wells, J. D. 1976. The fishery of Hyalite Reservoir during 1974 and 1975. M.S. Thesis. Montana State University, Bozeman.

Williams, J. E., J. E. Johnson, D. A. Hendrickson, S. Contreras-Balders, J. D. Williams, M. Navarro-Mendozza, D. E. McAllistor, and J. E. Deacon. 1989. Fishes of North America endangered, threatened, or of special concern: 1989. Fisheries 14:2-21.

Wipperman, A. H. 1965. Southwest Montana fishery study. Big Hole River sport fishery. Project F-9-R-13, Job No. I-A. Montana Department of Fish, Wildlife and Parks, Helena.

Yellowstone Fishery Assistance Office. 1991. Preliminary plan for restoration of fluvial Arctic grayling in Yellowstone National Park. U. S. Fish and Wildlife Service, Yellowstone National Park, Wyoming.

APPENDIX I

Streams Inspected On-Site

Gallatin River Drainage

Upper Gallatin River, Taylor's Fork to about 2 miles above Fan Creek

North and South Forks of Spanish Creek, near confluence

East Gallatin River, reaches in Gallatin Valley

Bridger Creek, tributary to East Gallatin River

Bozeman Creek, tributary to East Gallatin River

Madison River Drainage

Upper Gibbon River, Gibbon Falls to above Virginia Cascades

Canyon Creek, confluence at Gibbon River to about 1 mile upstream

Upper Firehole River, Kepler Cascades to above Lone Star Geyser

Cougar Creek, about 1 mile in vicinity of National Park Service cabin

South Fork of Madison, road and bridge access points from near Hebgen Reservoir to about 2 miles above Highway 191

Grayling Creek, sections above and below Highway 191 crossings

Beaver Creek, tributary to Quake Lake, from lake to about 3 miles above

Cherry Creek, on Turner Ranch

Jefferson River Drainage

Red Rock River

Elk Springs Creek, tributary to Upper Red Rock Lake, above and below refuge road crossing

Odell Creek, near Lakeview on Red Rock National Wildlife Refuge

Upper Red Rock River, dam at Lower Red Rock Lake and two bridges below

Red Rock Creek, above Upper Red Rock Lake

Long Creek, on road through BLM and Forest Service above Lima Reservoir

Ruby River

Middle Fork Ruby River, along Forest Service road

West Fork Ruby River, along Forest Service Road

Ruby River, along Forest Service road

Cottonwood Creek, near confluence with Geyser Creek

Beaverhead River

Reservoir Creek, above confluence with Grasshopper Creek

Frying Pan Creek, within Forest Service boundary

Bloody Dick Creek, below Reservoir Lake

Big Hole River

Big Hole River at road and bridge access points from Skinner Meadows to below Van Houten Lake

Jefferson River

Boulder River above confluence with Bison Creek

Bison Creek at bridge accesses from confluence to Elk Park

Halfway Creek, within National Forest

Smith River Drainage

South Fork Smith River, south and west of town of White Sulfur Springs

Newlan Creek, reservoir to highway 360 crossing

Birch Creek, west of White Sulfur Springs

North Fork Smith, near and above reservoir

Elk Creek, from Hound Creek to about 1 mile upstream

Crooked Creek, tributary to Hound Creek about 1 mile above mouth

Sun River

South Fork Sun River, near trailhead at Benchmark Campground

Sunny Slope Canal, from Pishkun Reservoir to Fairfield

Missouri River tributaries

Elkhorn Creek, above Holter Reservoir

Prickly Pear and McClellan creeks, near their confluence

APPENDIX II

Consultations with Regional Fisheries Biologists

The following fisheries biologists were consulted for suggestions and opinions on possible candidate streams within their geographic areas of management responsibility. Direct meetings were held with most, and telephone conversations with the remainder.

Jefferson, Ruby, Beaverhead, Red Rock, Big Hole, and Madison rivers

- Jim Brammer, U.S. Forest Service
- Pat Byorth, Montana Department of Fish, Wildlife and Parks
- Dick Oswald, Montana Department of Fish, Wildlife and Parks
- Dick Vincent, Montana Department of Fish, Wildlife and Parks

Gallatin, lower Jefferson, lower Madison, upper Missouri rivers

- Bruce May, U.S. Forest Service
- Ron Spoon, Montana Department of Fish, Wildlife and Parks
- Dick Vincent, Montana Department of Fish, Wildlife and Parks

Yellowstone National Park, Gallatin and Madison river tributaries

- Ron Jones, U.S. Fish and Wildlife Service
- Lynn Kaeding, U.S. Fish and Wildlife Service

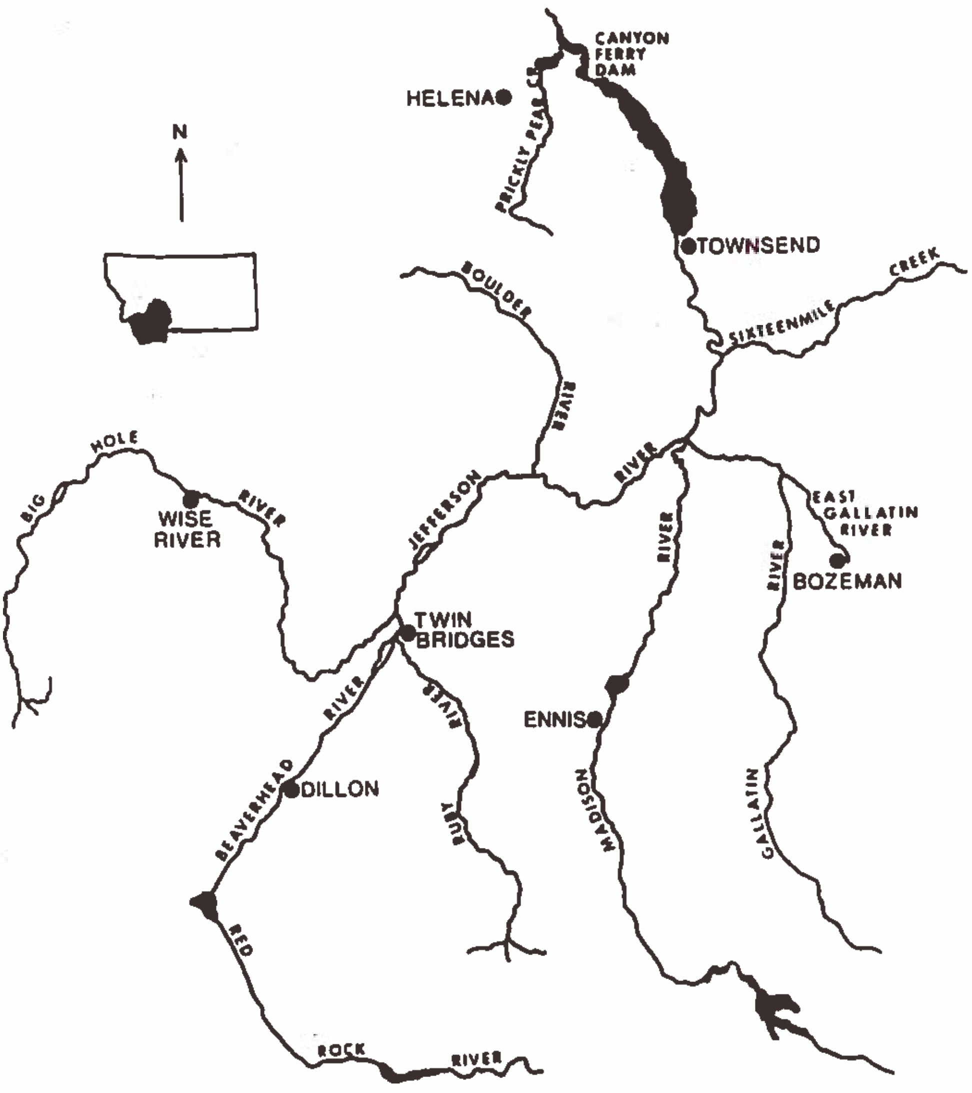
Missouri River below Canyon Ferry Reservoir, Sun, and Smith rivers

- Bill Hill, Montana Department of Fish, Wildlife and Parks
- Steve Leathe, Montana Department of Fish, Wildlife and Parks
- George Liknes, Montana Department of Fish, Wildlife and Parks
- Mark Lere, Montana Department of Fish, Wildlife and Parks
- Al Wipperman, Montana Department of Fish, Wildlife and Parks

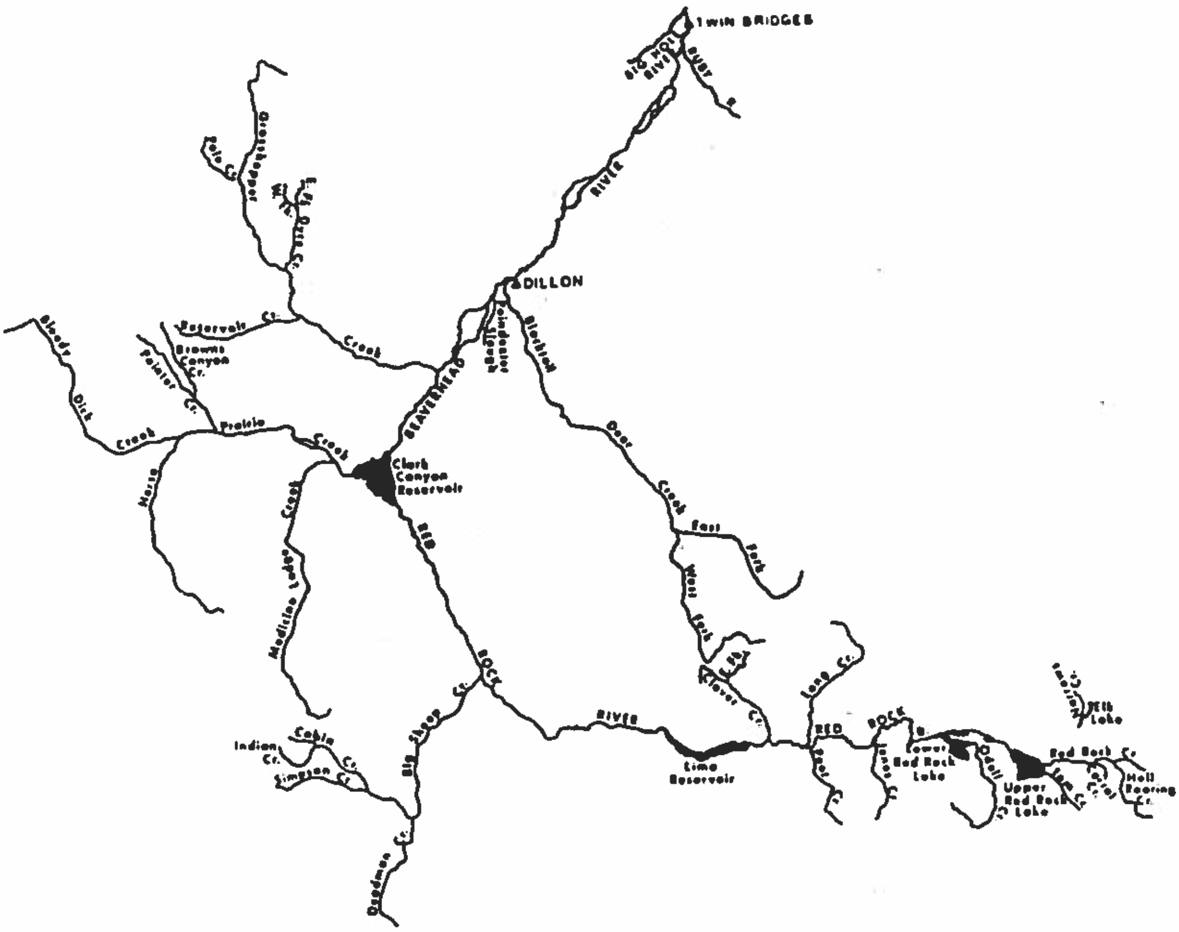
APPENDIX III

Maps of Drainages and Streams in the Upper Missouri Basin above Great Falls (All figures from MDFWP 1989a, 1989b)

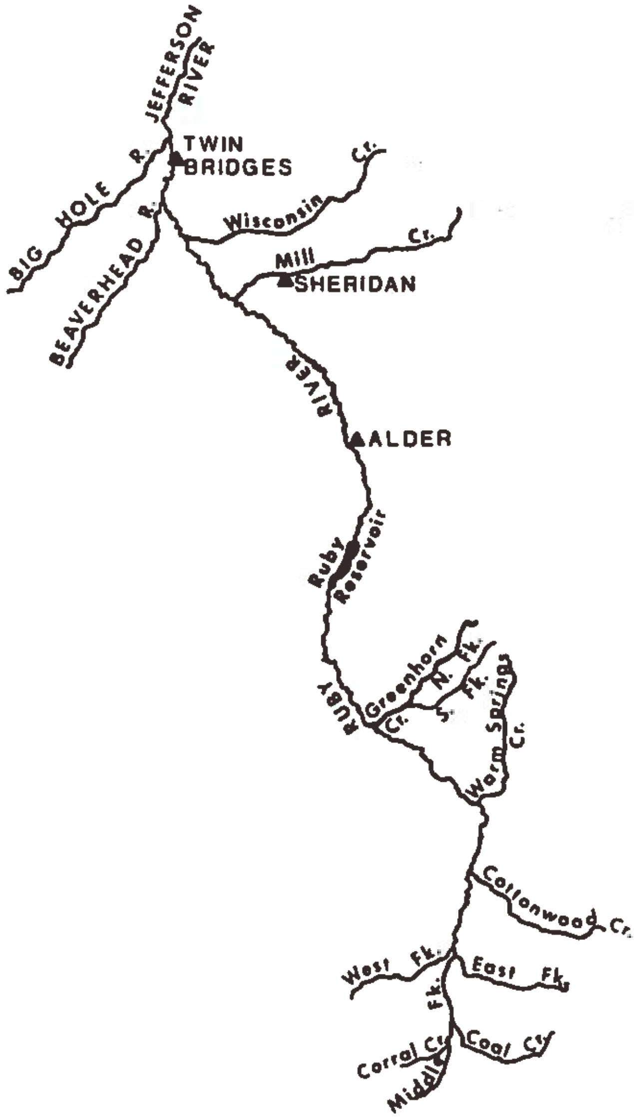
1. Major Drainages of the Missouri River Basin above Canyon Ferry Reservoir
2. Red Rock River and Beaverhead River and Tributaries
3. Ruby River and Tributaries
4. Jefferson River and Tributaries
5. Madison River and Tributaries
6. Gallatin River and Tributaries
7. Missouri River Tributaries between Holter Dam and Canyon Ferry Dam
8. Smith River and Tributaries
9. Sun River and Dearborn River and Tributaries



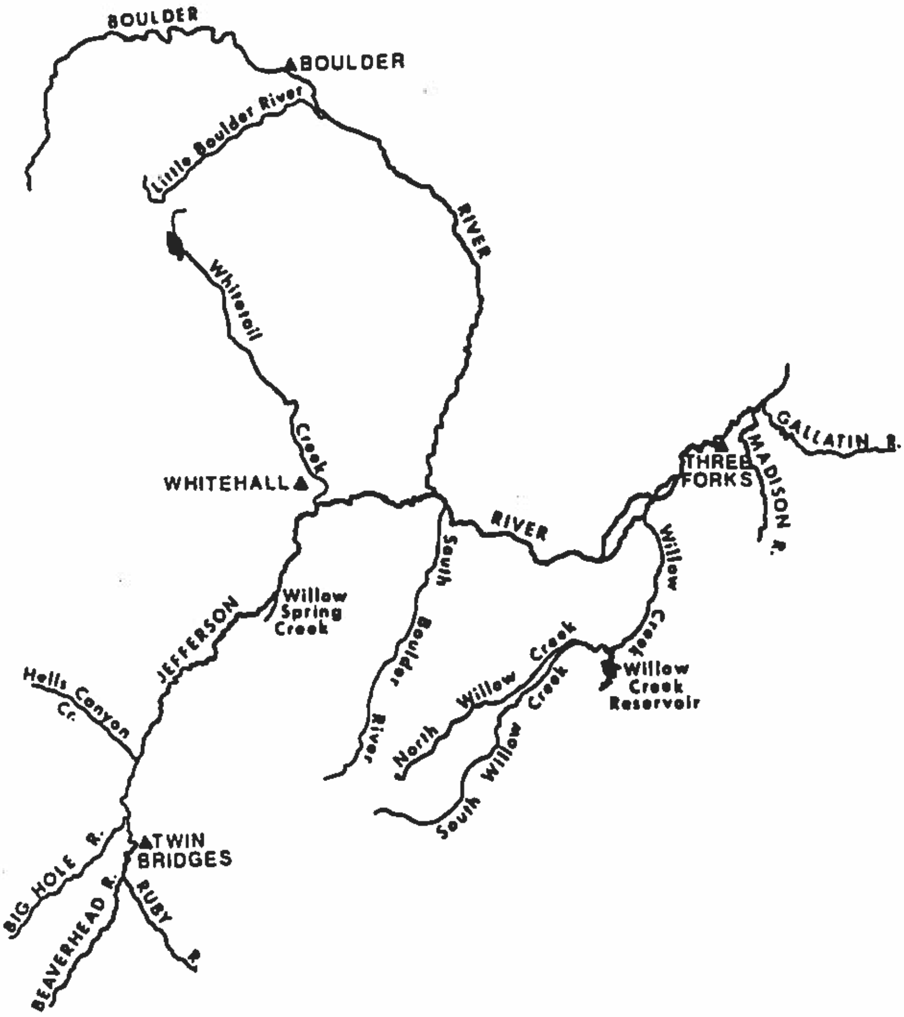
Appendix Figure 1. Major drainages of the Missouri River basin above Canyon Ferry Dam.



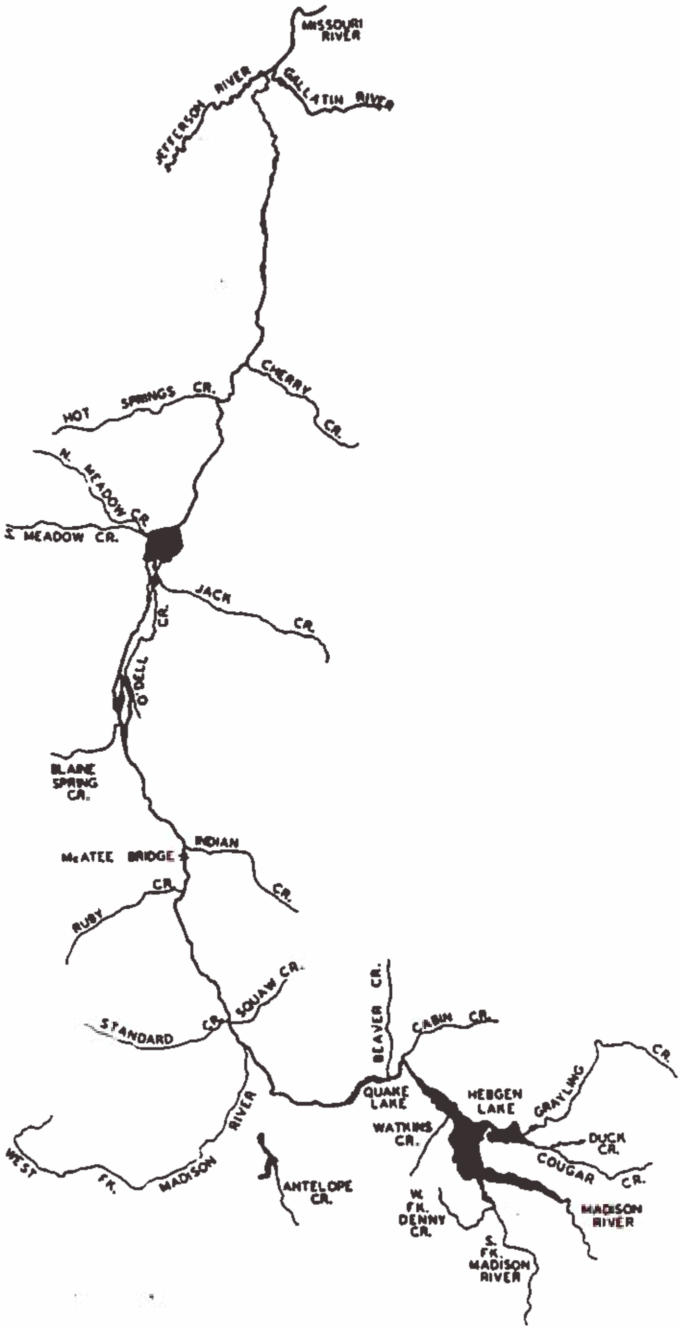
Appendix Figure 2. Red Rock River and Beaverhead River and tributaries.



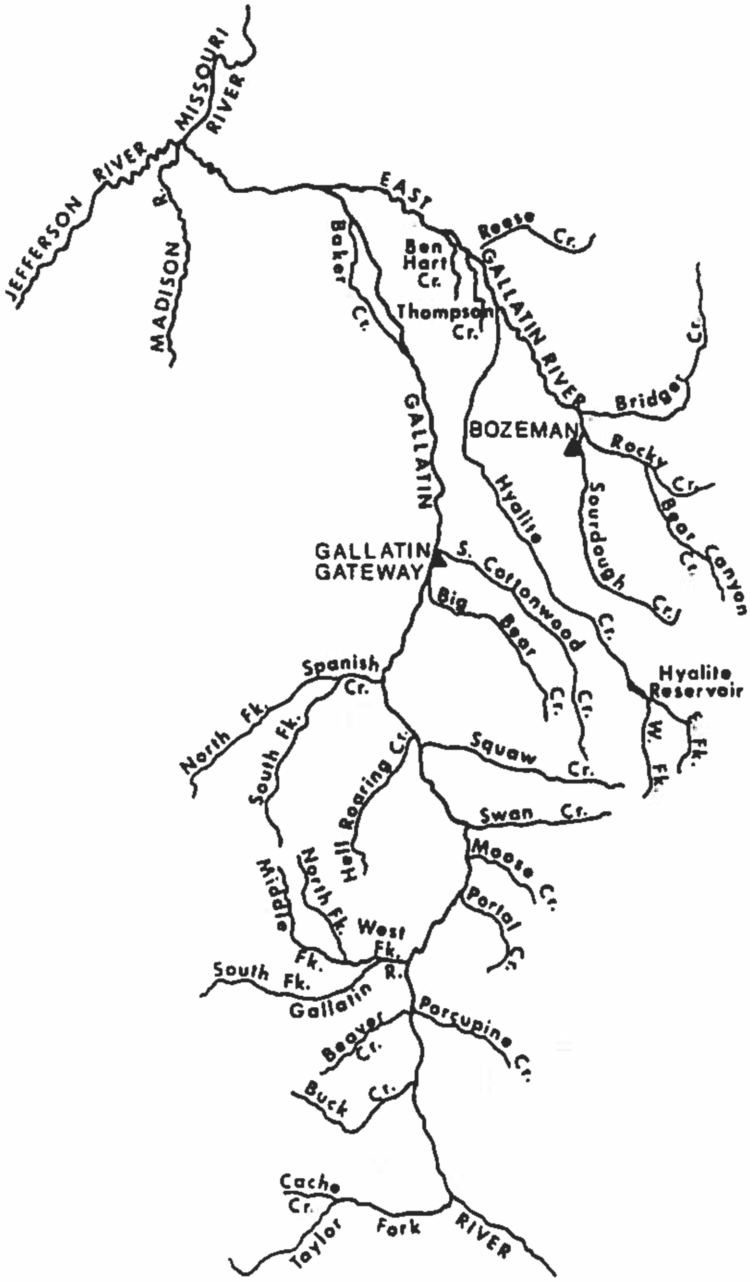
Appendix Figure 3. Ruby River and tributaries.



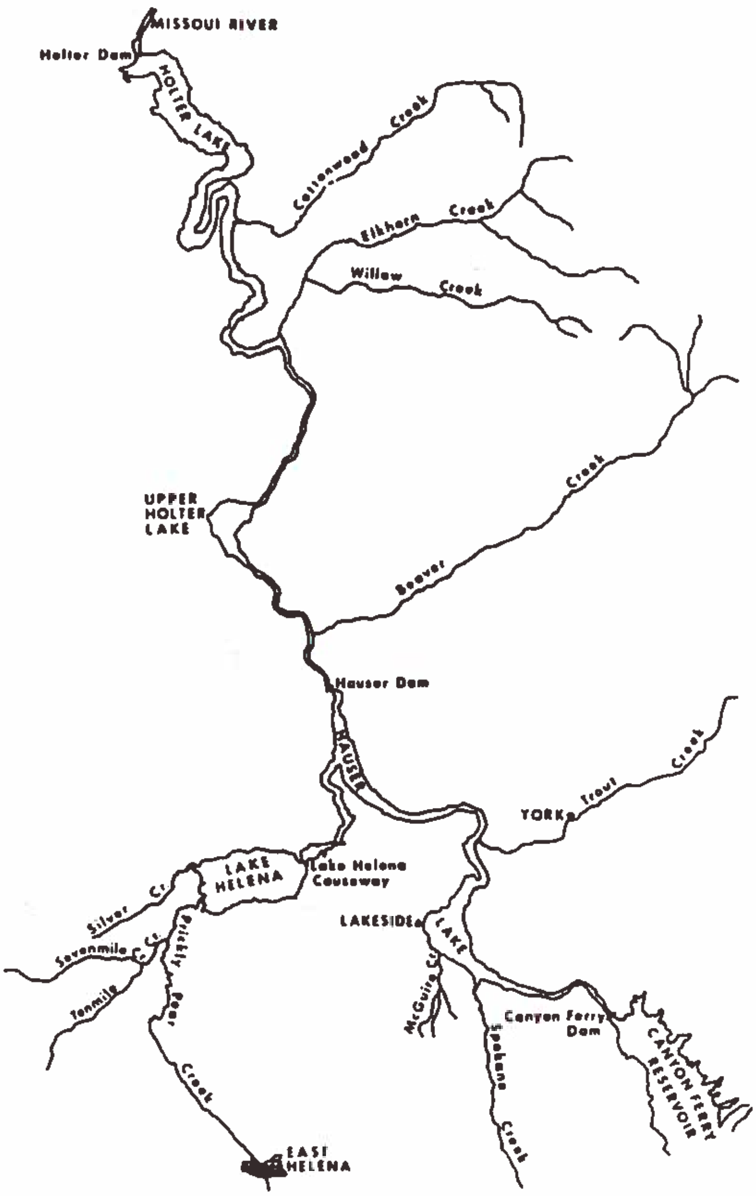
Appendix Figure 4. Jefferson River and tributaries.



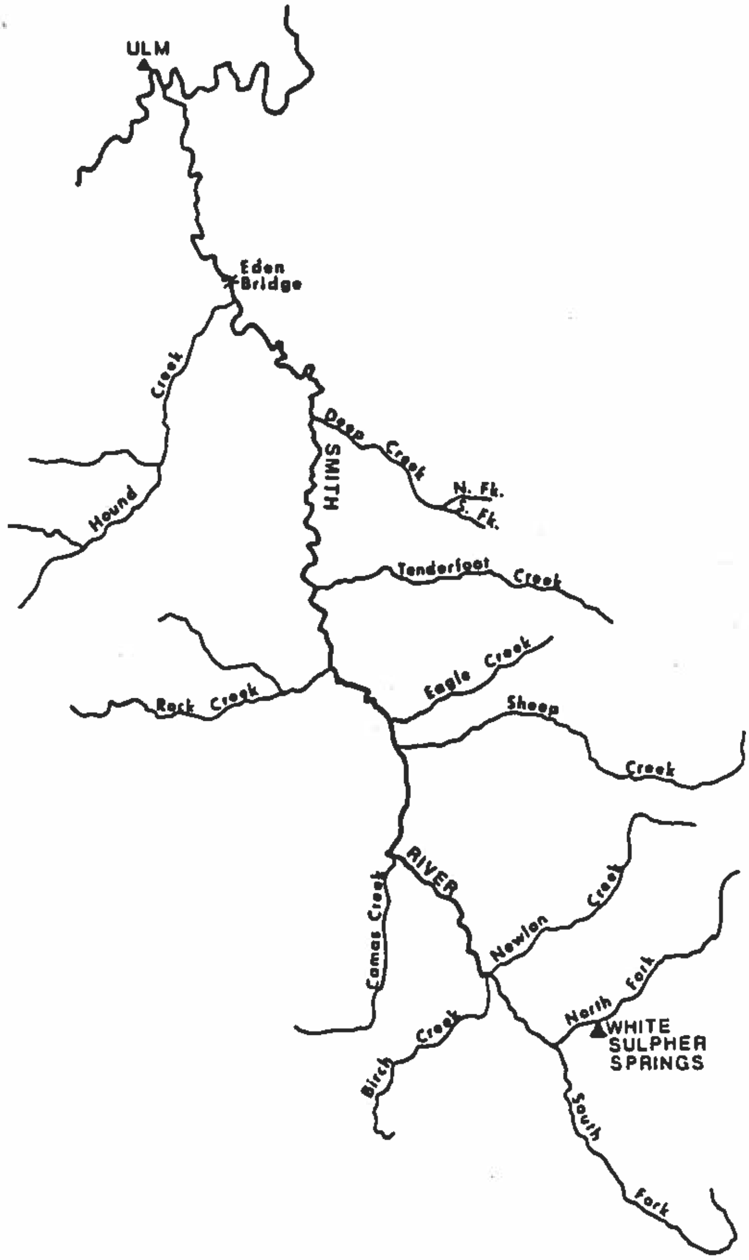
Appendix Figure 5. Madison River and tributaries.



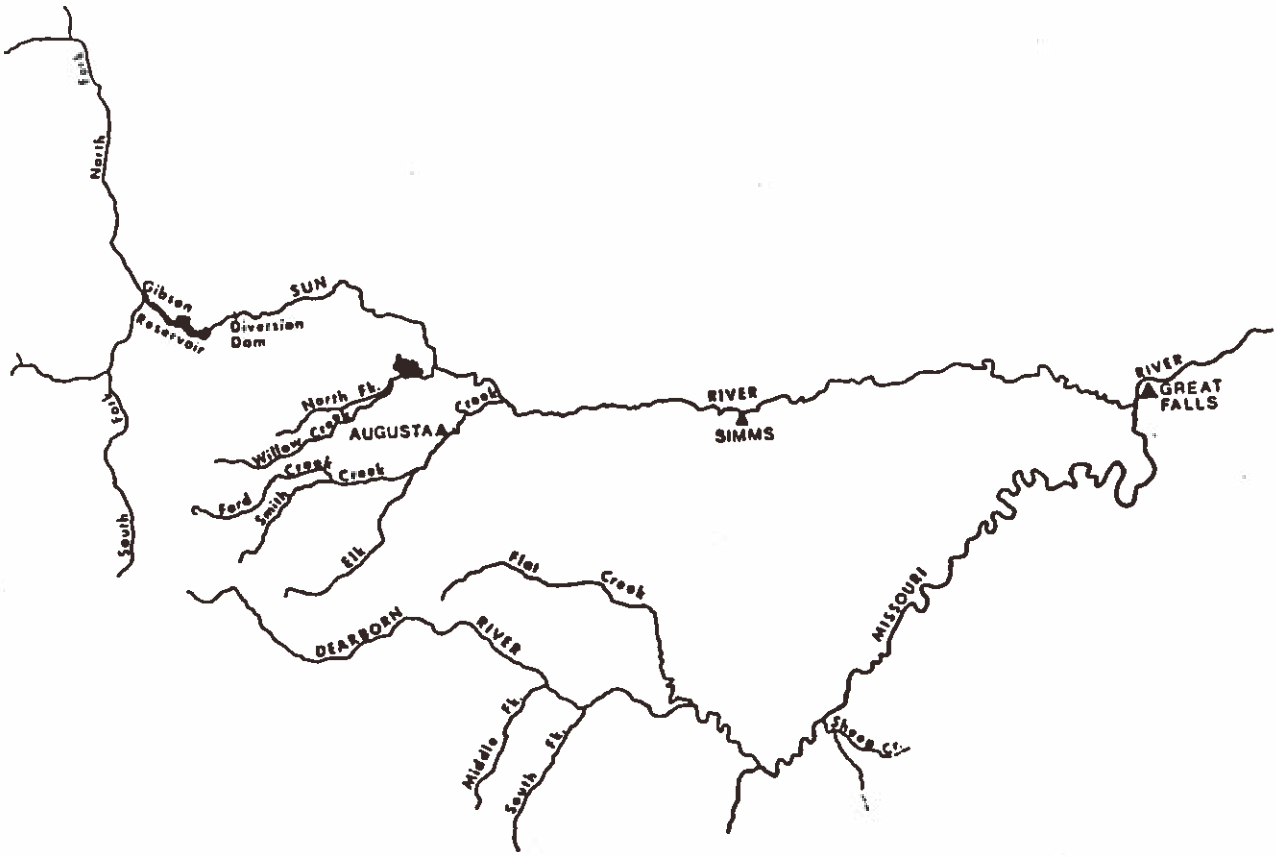
Appendix Figure 6. Gallatin River and tributaries.



Appendix Figure 7. Missouri River tributaries between Holter Dam and Canyon Ferry Dam.



Appendix Figure 8. Smith River and tributaries.



Appendix Figure 9. Sun River and Dearborn River and tributaries.