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ABSTRACT

As part of mitigation efforts for impacts of Cheyenne, Wyoming's Stage II transbasin water diversion project, the South Fork of Middle Crow Creek (SFMCC), a previously ephemeral stream is being used to convey water and create fish habitat. After two years of enhanced flow the amount of stream channel has increased 31% while beaver pond habitat has more than doubled. Brook trout have been stocked into the beaver ponds and provide some fishing opportunity. Limiting factors in the system include interrupted flow, discontinuous channels, and summer water temperatures in excess of 75° F. Analysis using the Physical Habitat Simulation System indicates that a flow of 2.5 cubic feet per second would maximize the amount of brook trout habitat in the SFMCC under present channel conditions.

INTRODUCTION

With the ever increasing demand for water in the western United States, more efficient utilization of existing supplies is needed. A goal of any water development project should be to maximize benefits to the greatest number of water users. These water users generally fall into four main categories; 1) agriculture, 2) municipalities, 3) industry, and 4) recreation. A common method for a municipality to obtain water for its use by transbasin diversion. Such projects can have dramatic effects on the streamside zone below the point of diversion by reducing or

eliminating streamflow, resulting in impacts to the riparian and aquatic resources.

Diverted water supplies are usually conveyed by means of either pipelines or open channels. An alternative method for conveyance is by using natural watercourses. If ephemeral streams are used, and flow releases are controlled and maintained year-round, new riparian and aquatic habitat can be created. To date, such a strategy has received little attention. Currently, however, the city of Cheyenne, Wyoming is pursuing such a strategy as one mitigation measure for its water development program.

Currently, a comprehensive study is underway at the Wyoming Water Research Center to assess the results of this action and the feasibility of applying this strategy to other watersheds. The overall project is focusing on defining conveyance efficiency, channel development, groundwater storage, alteration of riparian vegetation, and formation of trout habitat. This paper discusses the formation of trout habitat in the watershed after two years of enhanced flow. This part of the project was done in cooperation with the Wyoming Cooperative Fish and Wildlife Research Unit (Wolff 1987).

DESCRIPTION OF STUDY AREA

The stream selected for flow enhancement was the South Fork of Middle Crow Creek (SFMCC) and one of its tributaries. The SFMCC is located within the North Platte River basin of southeast Wyoming, 20 miles east of Laramie. The headwaters of this once ephemeral stream rise on the east slope of the Sherman Mountains at an elevation of 8,200 ft above mean sea level. The drainage runs in an easterly direction for 10 miles to its confluence with the Middle Fork of Crow Creek between Granite Springs and Crystal Lake Reservoirs. The upper 5.5 miles of stream is located within the boundaries of the Medicine Bow National Forest, while the lower 4.5 miles is on private land. For this project, the primary study area has been limited to the portion of the SFMCC watershed that is located on national forest lands.

Historically, the SFMCC was an ephemeral foothills stream which flowed primarily in response to spring snowmelt and intense summer thundershowers. Scattered springs and seeps throughout the drainage provided limited areas of surface flow during non-runoff periods. Only a portion of the drainage had a defined stream channel.

Municipal water was first released into the SFMCC during the

late summer of 1985. Presently, one cubic foot per second (cfs) is being discharged into both the main and tributary channels, with maximum potential releases of five and three cfs, respectively. In conjunction with the flow augmentation, six livestock exclosures were established in the lower reaches of the study area to provide protection for the developing aquatic and riparian, resources.

No fish were observed in 1985 within the study area. Brook trout (Salvelinus fontinails) were seen in the SFMCC prior to flow augmentation outside the study area near its confluence with the Middle Fork of Crow Creek. A total of 1,700 fingerling brook trout were planted in seven beaver ponds in the lower reaches of the SFMCC by the Wyoming Game and Fish Department in June of 1936 and 1987.

METHODS

Six Parshall flumes were installed on the SFMCC in 1985 and 1986 to monitor the hydrologic response of the watershed to enhanced flow. Flumes were equipped with water stage recorders for continuous monitoring. A thermograph was installed in 1987 in the lower channelized sections of the SFMCC to monitor stream temperature.

Evaluation of fish habitat development on the SFMCC was divided into two categories, measurement of stream habitat and measurement of ponded habitat. Work began in both areas in July 1935 as part of a baseline survey done on the SFMCC.

Ten General Habitat (GH) sites were established in reaches of well developed channel and sampled annually from 1935 through 1987. The purposes of the GH sites were to estimate the suitability of the stream sections for sustaining brook trout. Each GH site consisted of three channel cross-sections permanently marked with steel stakes (headstakes) on both the right and left banks. Cross-sections were placed 5-7 channel widths apart so that the length of the entire reach was 10-14 channel widths. A permanent benchmark was established at each site to ensure that the elevations of the headstakes did not change during the course of the study.

Sampling at GH sites consisted of attaching a measuring tape across the top of a cross-section and measuring tape height, water depth and water velocity at 10-15 points across each transect. Channel width, wetted width, dominant substrate and cover were also measured at each cross-section.

Wesche (1980) developed criteria for water velocity, water depth and substrate to assess habitat suitability for brook trout in southeastern Wyoming streams. These criteria are presented in Table 1. To assess the habitat suitability of the SFMCC at each GH site; mean velocity, mean depth and dominant substrate type were calculated for each cross-section at each GH site in both 1985 and 1987. An evaluation was then 'made to determine how' many of the measured parameters at the GH site were within Wesche's (1980) criteria in each year.

To assess stream habitat quality two habitat models were used; the Habitat Quality Index (HQI) (Binns and Eiserman 1979, Binns 1982) and the Modified Habitat Quality Index (MKQI) (Kosel 1987). Both habitat models (HQI and MHQI) were applied to two, 300 ft stream reaches on the SFMCC, one low gradient and one moderate gradient, in 1986 and 1987.

The HQI was developed by the Wyoming Game and Fish Department to predict potential standing crop in Wyoming trout streams. Kozel (1987) modified the variables and equations of the HQI for use on streams located in the Medicine Bow National Forest. The MHQI has separate equations for different trout species and channel types, classified following Rosgen (1985). For this study Kozel's models for brook trout in low gradient (< 1.5%) and moderate gradient (1.5% to 4.0%) stream channels were used.

Habitat-discharge relations were developed for four sites on the SFMCC using the Physical Habitat Simulation System (PHABSIM) developed by the U.S. Fish and Wildlife Service (Bovee 1982, Milhous et al. 1984). Habitat analysis was done for both adult and spawning brook trout. Habitat utilization curves for use in PHABSIM were developed from data in Reiser and Wesche (1977) and Wesche (1980). These data were obtained from fish populations in nearby similar streams.

TABLE 1. Stream habitat suitability criteria for brook trout (Salvelinus fontinalis) from Wesche (1980).

Parameter	Criteria
Water velocity (fps)	0.0 - 1.50
Water depth (ft)	> 0.4
Dominant substrate (% gravel and rubble)	> 50

The quantity and quality of beaver pond habitat was measured in 1985, 1986 and 1987. Surveys were made to determine the location, number and size of existing ponds. Ponds greater than 0.1 acres (surface area) were mapped to determine actual surface area, water surface elevation and mean depth. Mapping was done using standard transit-stadia survey techniques. Smaller ponds (< 0.1 acre) were noted as to size and location.

To evaluate the habitat quality of the SFMCC ponds, comparisons were made to other ponds in the Pole Mountain Recreation Area for which standing stock estimates have been made. Also, Winkle (1988) developed a method to predict standinc stocks in Wyoming beaver ponds. Though final results of that work were not completed in time for use in this study, much information from Winkle (1988) was used to assess the SFMCC beaver ponds as brook trout habitat.

To determine the survival of the stocked brook trout in the beaver ponds, the largest pond in each complex was sampled with two gill nets (30 x 3 ft, 4 panels of .25, .5, .75 and 1.0 inch mesh) set overnight in September 1987. Data on lengths and number caught were recorded.

RESULTS

Mean monthly flows (not including periods when discharge was zero) for stream gages operated on the SFMCC ranged from 0.4 to 1.7 cfs The duration of periods when flow into the SFMCC was turned off during the course of this. study ranged, from two to 31 days, and totaled 121 days (15%) during the first 27 months of flow enhancement.

Since flow augmentation began In 1985, 31% more stream channel (1,969 ft) has developed, though only 32% (8,404 ft) of the valley floor within the study area is channelized. Of the 1,969 ft of new channel, almost all of it developed by downcutting. In 1987, surveys indicated that in several of the unchannelized meadow areas the water was becoming more confined (i.e. decreased top width, increased velocity, increased depth), a precursor to channel development.

In 1985, 39 of a possible 90 (43%) measured habitat parameters fell within the suitable range. By 1987, 72 (80%) of the measured parameters fell within the suitable range. The greatest change took place in dominant substrate, which went from 3 transects within the criteria in 1985, to 27 within the suitable range by 1987.

All habitat quality ratings at the moderate gradient site were the same in 1936 and 1987, so standing stock predictions were the same for both years. These ratings yielded estimates of 100 lb/acre and 47 lb/acre for the HQI and MHQI, respectively. At the low gradient site a large discrepancy in standing stock estimates between the two models was shown. The HQI standing stock estimate at the low gradient site was 21 lb/acre in 1986 and 37 lb/acre in 1987. The MHQI estimate for the same site was 485 lb/acre in 1986 and 401 lb/acre in 1987. The increase in the HQI, and the decrease in the MHQI estimates, was due to an increase in the amount of cover from the first to the second year. The principal reason for such a large difference between the results of the two models is that the MHQI does not have a component to rate stream temperature like the HQI. Late summer stream temperature in the low gradient section of the SFMCC exceeded 25° F, beyond the suitable for brook trout.

The PHABSIM analysis showed that the maximum amount of adult habitat (reported as weighted usable area) in the SFMCC occurred at a discharge of 4.5 cfs, while the maximum amount of spawning habitat occurred at a discharge of 0.5 cfs. The maximum combination of both adult and spawning habitat occurred at a discharge of 2.5 cfs

All beaver ponds on the SFMCC were within three pond complexes. The amount of beaver pond habitat on the SFMCC increased in both 1986 and 1987. The increase was due to both an increase in the number of ponds and an increase in the size of existing ponds, in 1985, there were eight beaver ponds with a total surface area of 1.5 acres; in 1986 there were 14 ponds with 1.65 acres; and by 1987 there 24 ponds (an increase of 300% from 1985) having a surface area greater than 3.1 acres (an increase of over 100% from 1985).

Although standing stocks in beaver ponds on the SFMCC are not known, data from Winkle (1988) indicate that similar ponds in the Pole Mountain Recreation Area have standing stocks ranging from 1 to 55 lb/acre. However, the SFMCC ponds are unique in the relatively high and constant flow of water they receive. Winkle (1988) found that stable water levels in beaver ponds of this area is correlated with high brook trout standing stock. The enhanced flow on the SFMCC should result in stable water Levels in the beaver ponds and possible result in relatively high standing stocks.

Of the three ponds sampled by gillnets, only the ponds in complexes two and three were found to contain brook trout. Fish caught in complex two showed two distinct size classes, one at 7.5 inches and another at 12 inches, although only two fish were in the larger size class. Only one size class (7.5 inches), was found in complex three. These data seem to indicate that fish

survived both the 1986 and 1987 stocking in complex two, but only the 1987 stocking in complex three.

DISCUSSION

Stream habitat on the SFMCC had not changed a great deal after two years of enhanced flow. The overall length of developed channel increased 31%. Few other studies are known that have dealt with channel changes due to flow enhancement (Kellerhals et al. 1979, Bergman and Sullivan 1963), and no studies were found that deal with controlled flow releases into ephemeral stream channels for mitigation purposes. Overall, only 32% of the valley length within the study area has a channel, most of which is in the higher gradient sections of the SFMCC, but there are indications that more channel will form in the coming years. The development of a channel in the lower-gradient, meadow sections of the drainage will probably occur when the root masses of the meadow vegetation deteriorate to allow erosive processes to take over.

Based on habitat analysis, using both transects (GH sites) and models (HQI and MHQI), stream sections of the SFMCC seem to be suitable for brook trout. However, there are three factors limiting establishment of a fishery on the SFMCC -- interrupted flow, discontinuous channels and high summer water temperatures.

Of the three factors felt to limit the development of a sport fishery in the SFMCC, two are expected not to be problems in future years as the channel system develops. The developed channel on the SFMCC is not continuous, but occurs in sections, . so the availability of most of the stream habitat to brook trout is currently limited to stocking. However, as stated earlier, it is expected that channel will continue to develop on the SFMCC and will eventually be continuous throughout the system.

Summer water temperature appears to be a problem in the lower reaches of the SFMCC. Water flows through large, unchannelized meadows where it warms considerably before running into the downstream sections. Maximum suitable water temperature for adult brook trout is reported to be 75° F (MacCrimmon and Campbell 1969). In August 1987, stream temperatures were recorded in excess of 75° F on several occasions. Using a stream temperature model developed by the U.S. Fish and Wildlife Service (Bartholow 1985), predictions were made of maximum stream temperature on the SFMCC assuming that the entire valley length was channelized. This model indicated that temperatures would not exceed 65° F. So, if a channel does develop along the entire length of the SFMCC study area, water temperature should no

longer be a limiting factor. Also, if the temperature rating in the HQI is adjusted to reflect the predicted 55" F maximum stream temperature, the standing stock estimate at the low gradient reach increases to 205 lb/acre, more similar to the MHQI estimate.

The results of the PHABSIM analysis are Important from the city of Cheyenne's perspective. The discharge on the SFMCC which maximizes fish habitat is about one-quarter of what could be required for release. This could significantly reduce the amount of water lost to the city through conveyance and increase their economic benefits. However, it should be noted that as the SFMCC channel changes over time, the optimum discharge (in regards to fish habitat) will probably change also.

In contrast to the stream habitat, a large increase in the amount of beaver pond habitat, 300% in the number of ponds and over 100% in surface area, was seen from 1985 to 1987. This is important because it is beaver pond habitat that supports the sport fishery for brook trout in the Pole Mountain Recreation Area (Call 1960 and 1966, McDowell 1975, Snigg 1986).

The deciding factor on whether or not the SFMCC develops into a productive sport fishery, and thus making this mitigation attempt a success, is obtaining the uninterrupted flow that is called for in the project plans. The frequency and duration of interrupted discharge during the first two years indicated that a productive fishery will be severely limited if current water management policies are maintained for the SFMCC.

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LITERATURE CITED

Bartholow, J. 1985. Stream Reach Temperature Model (SRTEMP). Program Documentation. U.S. Fish and Wildlife Service. Fort Collins, Colorado.

Bergman, D.L. and C.W. Sullivan. 1963. Channel changes on Sandstone Creek near Cheyenne, Oklahoma. Professional Paper 475-c, U.S. Geological Survey.

Binns, N.A. 1982. Habitat Quality Index manual. Wyoming Game and Fish Department, Cheyenne.

Binns, N.A. and F.M. Eiserman. 1979. Quantification of fluvial trout habitat in Wyoming. Transactions of the American Fisheries Society 108:215-228.

Bovee, K.D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Methodology. Instream Flow Information Paper No. 12. FWS/OB3-82/26.

Call, M.W. I960. A study of the Pole Mountain beaver and their relation to the brook trout fishery. M.S. Thesis, University of Wyoming, Laramie.

Call, M.W. 1966. Beaver pond ecology and beaver-trout relationships in southeastern Wyoming. Ph.D. Dissertation, University of Wyoming, Laramie.

Kellerhals, R., M. Church and L.B. Davies. 1979. Morphological effects of interbasin river diversions. Canadian Journal of Civil Engineering 6:18-31.

Kozel, S. 1987. Trends in habitat features and trout abundance among unaltered stream reaches on the Medicine Bov National Forest. M.S. Thesis. Department of Zoology and Physiology. University of Wyoming, Laramie.

MacCrimmon H.R. and J.C. Campbell. 1969. World distribution of brook trout, Salvelinus fontinalis. Journal Fisheries Research Board of Canada. 26:1699-1725.

McDowell, R.A. 1975. A study of the Pole Mountain fishery: beaver pond, artificial impoundment and stream investigations. Completion Report DJ/F-44-R-01. Wyoming Game and Fish Department, Laramie.

Milhous, R.T., D.L. Wagner and T. Waddle. 1984. Users guide to the Physical Habitat Simulation System (PHABSIM). Instream Flow Information Paper No. II. FWS/OBS-81/43 (revised 1984).

Reiser, D.W. and T.A. Wesche. 1977. Determination of physical and hydraulic preferences of brown and brook trout in the selection of spawning locations. Water Resources Research Institute Publication No. 64. University of Wyoming, Laramie.

Rosgen, D. 1985. A stream classification system. Riparian ecosystems and their management: reconciling conflicting uses. First North American Riparian Conference, Tucson, AZ. GTR-RM-120. Rocky Mountain Forest and Range Experiment Station. U.S. Forest Service.

Snigg, M. 1986. Pole Mountain beaver pond re-inventory project report 5085-13-7301. Wyoming Game and Fish Department, Laramie.

Wesche, T.A. 1980. The WRRI trout cover rating method. Water Resources Research Institute Publication No. 78. University of Wyoming, Laramie.

Winkle, P.W. 1988. A Habitat Quality Index for beaver ponds in southeastern Wyoming. M.S. Thesis. University of Wyoming, Laramie.

Wolff, S.W. 1987. Evaluation of trout habitat formation due to flow enhancement in a previously ephemeral stream. M.S. Thesis. University of Wyoming, Laramie.