Prepared for the Michigan Academy of Science, Arts and Letters, 1953.

Original: Mich. Acad. Sci., Arts and Letters
cc: Fish Division
Education-Game
Institute for Fisheries Research
D. S. Shetter

February 17, 1953

Report No. 1357

THE EFFECT OF AN IMPOUNDMENT ON THE WATER TEMPERATURE OF FULLER CREEK, MONTMORENCY COUNTY, MICHIGAN [1]

by

David S. Shetter and Marvin J. Whalls

Abstract

The effect of an impoundment on the water temperatures of Fuller Creek, one of the experimental waters of the Hunt Creek Fisheries Experiment Station, in Montmorency County, Michigan, was investigated by comparing average daily midsummer (June, July, August) and midwinter (January, February, March) air and water temperatures for three years before, and three years after, replacement of the Fuller Creek beaver dam in May, 1949. Temperature data were obtained from a recording thermograph located about one mile downstream from the re-established pond and operated more or less continuously for the period 1942-1952.

Fuller Creek average daily water temperatures were found to be consistently and significantly higher in midsummer months in the post-dam period than in the pre-dam period, by 6.5 to 10.1 degrees F. These increases did not seem to be associated with changes noted in the average daily air temperatures. Midsummer average discharge rates for Fuller Creek appear to have been the same for June and July through the investigation, possibly slightly

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[1] Contribution of the Michigan Institute for Fisheries Research

higher during the Augusts of the post-dam period. Midwinter average daily water temperatures were from 0.82 to 2.75 degrees higher in the post-dam period, but the increases noted coincided with significant increases in air temperature and significant decreases in stream flow in the post-dam period.

The increase in average daily midsummer water temperature did not change the angling quality for brook trout significantly during the period of investigation.

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The effect of an impoundment on the water temperature of Fuller Creek, Montmorency County, Michigan

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Beaver dams have been traditionally regarded as ideal trout habitat by trout fishermen, primarily because a population of trout often is concentrated in a comparatively small area where they may be fished over readily. Also many beaver ponds yield trout whose average size often is greater than for fish found under normal stream conditions. No fisheries manager can object to these two general characteristics of beaver-made impoundments, but he must weigh these favorable aspects against known undesirable effects of beaver dams on the stream drainage below, as well as above, the site of beaver activity. Perhaps the most important consideration is the effect of beaver impoundments on the stream water temperatures in areas further downstream. An excellent opportunity to study the effect of an impoundment on trout stream temperatures has existed on the experimental waters of the Hunt Creek Fisheries Experiment Station in southwestern Montmorency County, Michigan, since the inception of the station in 1939. This paper describes the observations made in connection with the changes resulting from re-establishment of an old beaver dam, on the subsequent stream temperatures below the dam.

Description of stream conditions

When the station was established in 1939, the Fuller Creek Pond (see map, Fig. 1) impounded about 12 acres of water. The

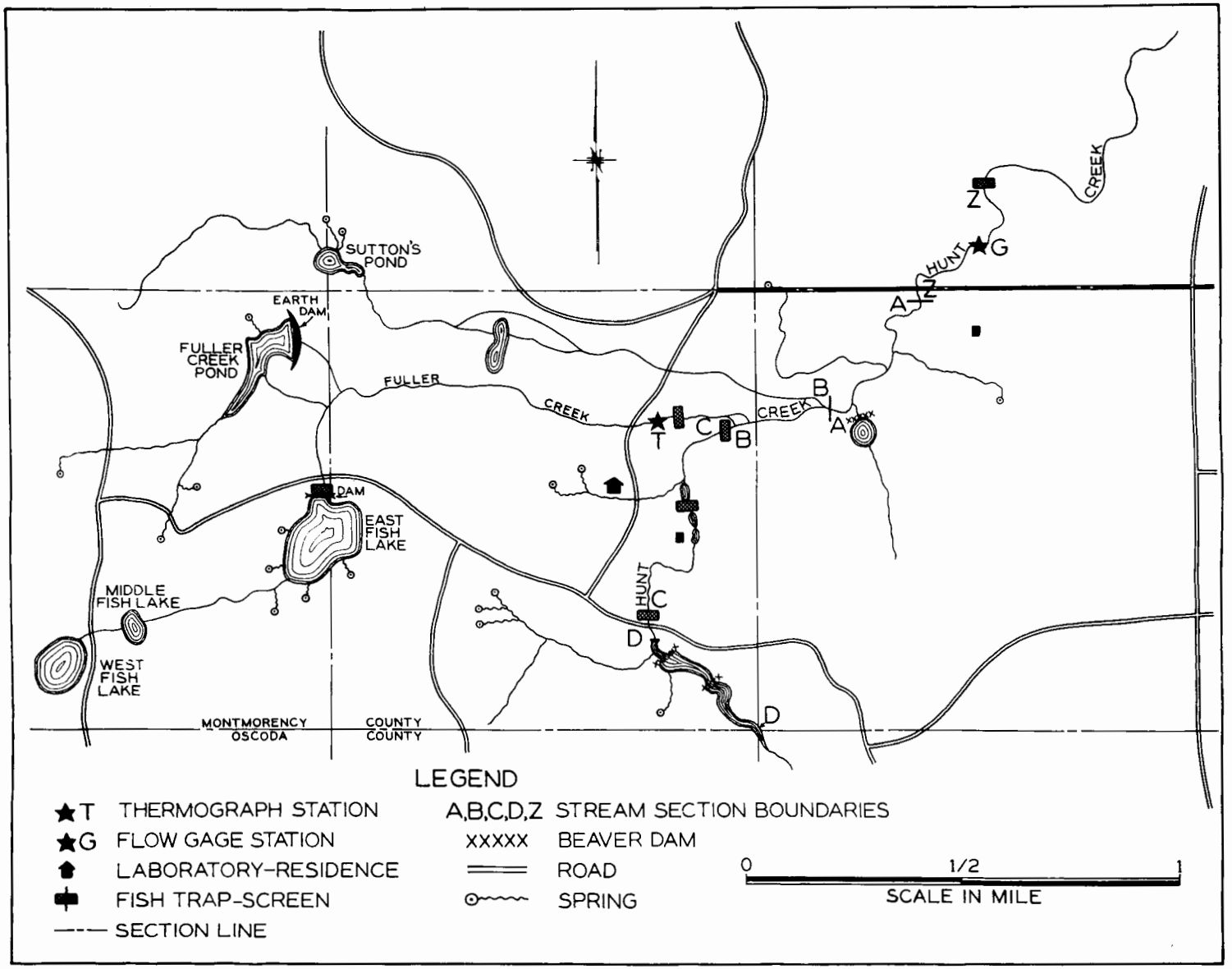

Figure 1. Map of Hunt and Fuller creeks in the vicinity of the Hunt Creek Fisheries Experiment Station, Montmorency County, Michigan. Roads and stream courses were traced from Conservation Department aerial photographs made in 1938.

pond was very irregular in shape and flooded much standing cedar, spruce and tamarack. The origin of the water impounded by the beaver is primarily springs, which at their source have temperatures ranging from 46 to 50 degrees F. Because the beaver dam spread these waters over a considerably greater area than the originally shaded stream channel, the waters were exposed to the warming effects of the sun's rays. During periods of high summer temperatures the surface waters of the Fuller Creek Pond at the dam were noted to reach temperatures of 70-80 degrees F. when the air temperatures were 80-90 degrees F. Although the date of establishment of the dam has never been determined accurately, our observations plus accounts of local fishermen suggest that the beaver built it about 1935.

About 200 yards below the Fuller Creek Pond, the waters of Fuller Creek are further augmented by the outflow of East Fish Lake. In periods of hot summer weather this lake water is relatively warm--it often reaches 80 degrees. The East Fish Lake outlet water is tempered slightly by limited spring-water seepage between the lake and its confluence with Fuller Creek.

Below the confluence of Fuller Creek and East Fish Lake outlet, Fuller Creek flows easterly for about 3/4 mile through a narrow, steep-sided valley which is more or less completely occupied with a dense cedar-spruce-tamarack swamp. Considerable spring water, almost all of which is completely shaded, flows into Fuller Creek from the sides of the swamp valley, and this flow noticeably increases the volume of the stream, in the area above the road bridge. From the bridge downstream to the junction of Fuller and Hunt creeks, the bankside vegetative cover of Fuller Creek is of

more open character, although the stream flows mainly through what was originally a low, flat cedar swamp. The current of Fuller Creek varies from moderate in the upper portion to rapid and turbulent through the narrow valley, where it drops at least 25 feet in a half mile.

Fuller Creek Pond provided comparatively good fishing in 1939 and 1940 under rather heavy angling pressure. However, by 1942, much of the beaver dam had rotted and a large portion of the pond area had been lost. By 1943, the dam had lost its ability to retain a head of water, and the stream had returned to its original relatively narrow channel.

In January, 1942, a recording thermograph was installed on Fuller Creek about one mile downstream and east of the Fuller Creek Pond (at the point designated T on the map, Figure 1). At this site, any changes in water temperature induced by factors located upstream would be recorded. Except for three periods [1] a continuous record of the diurnal fluctuations of the air and water temperatures is available for analysis.

Because of the quality of the fishing which had been enjoyed on the former beaver pond during 1939 and 1940, the impoundment was re-established during May of 1949 by a Michigan Department of Conservation Lake and Stream Improvement crew (under the supervision of O. H. Clark). An earth-fill dam was erected on the site of the old beaver dam, and it was found that there was a natural spill at the proper elevation on the south side which permitted the approximate original level to be maintained.

The present pond differs from the original impoundment in that the water current does not flow the full length of the pond as it

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[1] During the periods May 1-October 11, 1943; September 3, 1948-January 3, 1949; and October 31, 1949-May 1, 1950 the thermograph was out of operation because of needed repairs.

did in the original body of water. A minor amount of seepage water is returned to the original channel (shown by a dotted line on the map, Fig. 1) because the dam is not sheet-piled. The major portion of the present outflow now follows the outlet shown on the south side of the pond. The lower ponded area receives little or no mixing effect that would be caused by a continuous channel through the impoundment. The area of the re-impounded beaver dam is 14.58 acres, according to a plane-table map made in September of 1950.

The re-establishment of Fuller Creek Pond provided an opportunity to compare stream temperatures for a period of years, when Fuller Creek had no impoundment in its course, with a period of years when an impoundment existed.

Method of study

Thermograph records for three years just prior to re-impoundment (1946, 1947 and 1948--a period for which Fuller Creek might be considered as normal) have been compared with the records for the three years (1949, 1950, and 1951) following re-impoundment. Average daily air and water temperatures were calculated for critical periods for which records are available. The critical temperature periods in a trout stream are generally during the months when the highest air temperatures prevail--June, July and August--and to some extent during the coldest months of the year--January, February and March.

The average daily temperatures were determined in a manner similar to that used by the U. S. G. S. in calculating average daily water flow, etc. from their recording instruments. A glass or plastic slide, on which a fine horizontal line is drawn, is

placed on the daily temperature record for any given day (midnight to midnight) with the ruled line parallel to the horizontal temperature isobars of the thermograph record. The position of the ruled line is adjusted vertically until equal areas, estimated visually, are produced above and below the ruled line and within the bounds of the temperature curve. The average daily temperature is read at that point where the ruled line crosses the temperature record to the nearest degree in Fahrenheit.

The average daily temperatures were then averaged to give monthly means, and means for the three Junes, three Julys, etc., for the two three-year periods which are compared.

Results of the tabulations

Average daily air and water temperatures for Fuller Creek, where the Junes, Julys, etc., before and after construction of the dam, have been combined, are listed in Table 1 (June, July, August) and Table 2 (January, February, and March). Figure 2 shows a comparison of before-and-after temperatures for June, July and August. The average of water temperatures for June of 1949-1951 exceeded that for July of 1946-1948 by 10.12 degrees F.; for July the corresponding difference was 8.83 degrees F.; and for August, 6.50 degrees F. These differences were of a magnitude important to the stream as a trout habitat. Obviously the differences were mostly the result of re-establishment of the impoundment; the differences can be related only to a small extent to differences in air temperatures. For June, the average of air temperatures in the post-dam period was 2.49 degrees higher than for the pre-dam period, while for July the post-dam figure was 0.63 degrees higher, but for August the post-dam figure was 2.31 degrees lower than the pre-dam figure.

Table I

Comparison of average midsummer air and water temperatures
for Fuller Creek before and after re-installation of Fuller Creek Pond

Month	Item	Period	Number of observations	Average daily temperature	Standard deviation	Standard error	S. E. of difference	t	P
June	Air	1946-1948	89	61.85	8.069	0.855	1.162	2.14	96.8
		1949-1951	90	64.34	7.464	0.787			
	Water	1946-1948	89	50.28	2.340	0.248	0.420	24.10	99.9+
		1949-1951	90	60.40	3.212	0.339			
July	Air	1946-1948	92	66.00	5.386	0.562	0.867	0.73	53.4
		1949-1951	82	66.63	5.985	0.661			
	Water	1946-1948	93	52.88	2.558	0.265	0.422	20.92	99.9+
		1949-1951	83	61.71	2.990	0.328			
August	Air	1946-1948	92	64.75	7.534	0.785	0.942	2.45	98.6
		1949-1951	72	62.44	4.420	0.521			
	Water	1946-1948	93	53.12	4.030	0.418	0.528	12.31	99.9+
		1949-1951	74	59.62	2.767	0.322			

Table II

Comparison of average midwinter air and water temperatures
for Fuller Creek before and after re-installation of Fuller Creek Dam

Month	Item	Period	Number of observations	Average daily temperature	Standard deviation	Standard error	S. E. of difference	t	P
January	Air	1946-1948	90	18.08	10.599	1.117	1.812	2.68	99.3
		1949-1951[1]	44	22.93	9.454	1.425			
	Water	1946-1948	90	34.32	1.729	0.182	0.374	2.19	97.1
		1949-1951	44	35.14	2.173	0.327			
February	Air	1946-1948	85	15.44	9.366	1.016	1.758	5.65	99.9+
		1949-1951	56	25.38	10.735	1.435			
	Water	1946-1948	85	34.65	1.848	0.200	0.466	5.90	99.9+
		1949-1951	43	37.40	2.760	0.421			
March	Air	1946-1948	93	28.58	11.225	1.164	1.585	0.21	9.5
		1949-1951	62	28.92	8.471	1.076			
	Water	1946-1948	93	36.51	3.409	0.353	0.456	2.70	99.3
		1949-1951	62	37.74	2.269	0.288			

[1] Thermograph not in operation during winter of 1950.

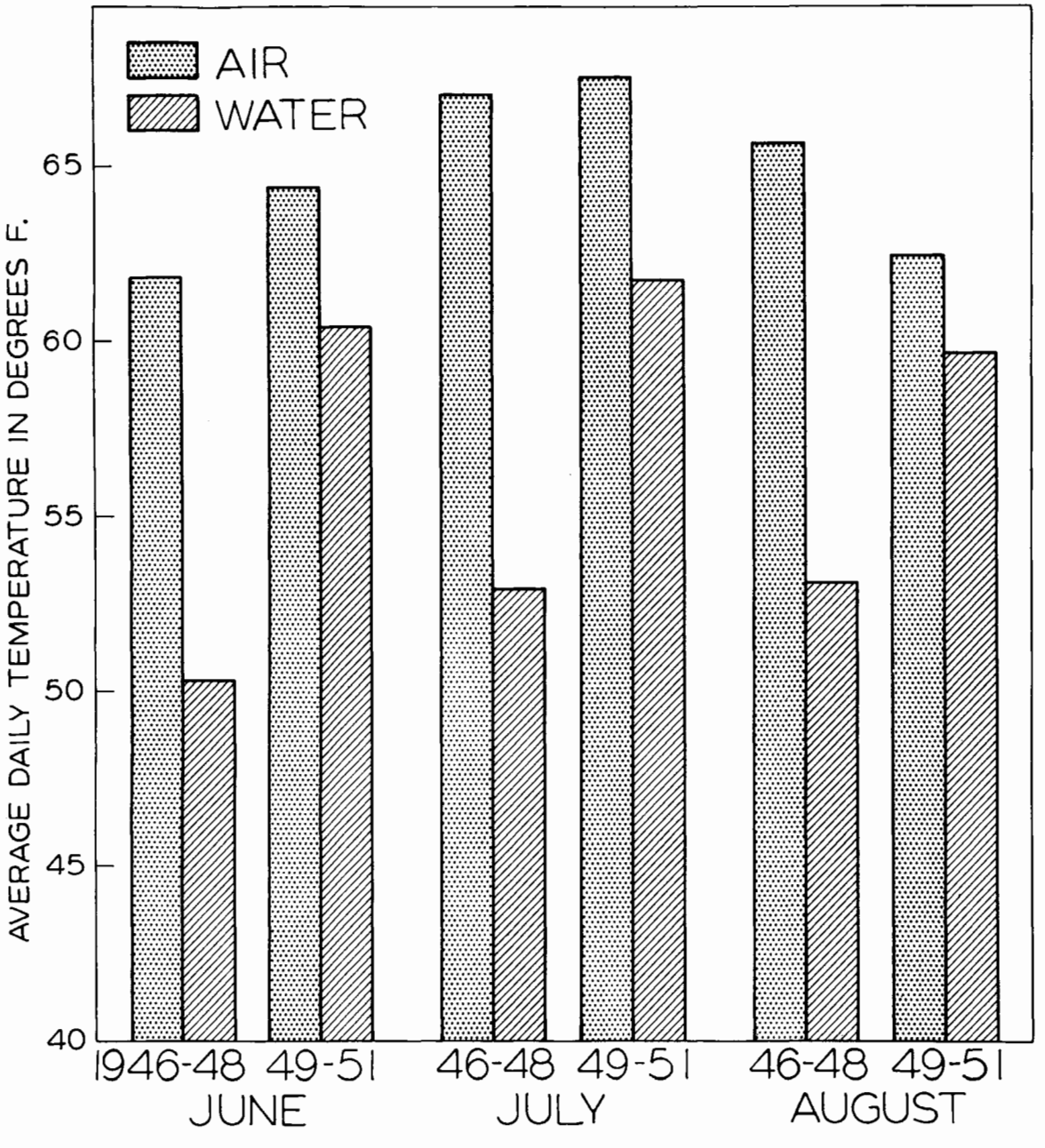

Figure 2. Average daily air and water temperatures for Junes, Julys and Augusts before re-installation (1946-1948) and after re-installation (1949-1951) of Fuller Creek dam. Data taken from Table 1.

Analyses of midwinter temperatures (January, February and March) also showed that the stream was slightly warmer in the period after re-installation of the dam (Table 2). Significantly colder, average daily air temperatures were recorded for the Januaries and Februaries in the period 1946-1948 than for the period 1949 + 1951, but average daily air temperatures for March were approximately the same in the two periods. Averages of daily water temperatures for individual winter months in the post-dam period were 0.82 to 2.75 degrees warmer than in the pre-dam period, and these differences were found to be statistically significant.

A possible factor which might have influenced water temperatures is variation in the flow of Fuller Creek during the period under consideration. Accurate data are not available for Fuller Creek, but stream flow records taken at the gaging station maintained by the U. S. G. S. on Hunt Creek (G in Figure 1), approximately 1½ miles downstream from the thermograph location, provide an accurate picture of the variation of the flow of the main stream of Hunt Creek. Inasmuch as Fuller Creek supplies a major portion of the Hunt Creek flow below its confluence with Fuller Creek, it is reasoned that any great variation in discharges of Fuller Creek would be reflected in the flow records of the main stream.

From the discharge records of Hunt Creek, averages were computed for the Junes, Julys, etc., both for the pre-dam and post-dam periods. According to these records the Hunt Creek discharge did not differ in its June flow, or its July flow, between the pre- and post-dam periods. For August, the data suggest a slightly higher flow in the post-dam periods. The flow records and results of statistical analysis are given in Table 3.

The discharge records for January, February and March show that midwinter discharges averaged greater by 1.5 c.f.s. (February comparisons) to 3.3 c.f.s. (March comparisons) in the pre-dam period. The differences are statistically significant (Table 3).

If it is granted that the data on discharges of Hunt Creek reflect the conditions in Fuller Creek, then the Fuller Creek discharge during the period of investigation may be summarized as follows: During June and July the flow remained approximately the same in the pre- and post-dam periods; in August there was a slightly greater discharge after installation of the dam. During the three midwinter months significantly greater amounts of water were discharged before the dam was installed.

The effect on Fuller Creek water temperatures of establishment of the Fuller Creek Pond, along with the variations noted in air temperature and postulated discharge variations, might be summarized as follows: Midsummer water temperatures were found to be significantly higher after replacement of the dam despite no apparent differences in water discharge rate and under varying conditions of air temperature. Although average daily water temperatures for the midwinter months showed a small but significant increase in the post-dam period, it does not appear possible to assign this increase to changes brought about by re-installation of the dam; it can be shown that the post-dam period had significantly higher average daily air temperatures along with significantly lower discharge rates. These latter factors may have been responsible for the rise in average daily midwinter water temperature in the post-dam years.

Table III

Comparison of midsummer and midwinter discharge rates (in cubic feet per second) of Hunt Creek before and after re-installation of Fuller Creek Dam

Month	Period	Number of observations	Average discharge (c.f.s.)	Standard deviation	Standard error	S. E. of difference	t	P
January	1946-1948	93	23.6	2.61	0.27	0.368	4.62	99.9+
	1949-1951	93	21.9	2.45	0.25			
February	1946-1948	85	22.8	2.18	0.24	0.347	4.32	99.9+
	1949-1951	84	21.3	2.17	0.24			
March	1946-1948	93	26.6	5.16	0.54	0.716	4.61	99.9+
	1949-1951	93	23.3	4.56	0.47			
June	1946-1948	90	23.6	3.36	0.35	0.610	0.49	37.6
	1949-1951	90	23.3	4.71	0.50			
July	1946-1948	93	22.5	6.08	0.63	1.018	0.79	57.0
	1949-1951	91	21.7	7.63	0.80			
August	1946-1948	93	20.0	2.86	0.30	0.716	1.81	93.0
	1949-1951	93	21.3	6.24	0.65			

It is concluded that the re-establishment of the Fuller Creek dam, with the resultant spreading of the water over several times the normal stream channel area, raised midsummer water temperatures from 6.5 to 10.1 degrees F. The effect of the dam on mid-winter average daily water temperatures was obscured partially by significantly higher average air temperatures in Januaries and Februaries of 1949 + 1951 combined with what is inferred to have been a significantly lower average discharge rate during this post-dam period.

The increase in midsummer water temperatures on Fuller Creek apparently did not change the quality of angling for brook trout in this stream, judging from intensive creel census records collected each year by the staff of the Hunt Creek Fisheries Experiment Station. The catch per hour per angler for 1946-1948 was 0.166, and for 1949-1951 it was 0.149; the difference (0.017) is not statistically significant (Table 4). The probable reason that the angling quality exhibited little change lies in the fact that the stream temperature increase after replacement of the dam, although of statistically significant proportions, was well within the limits of physiological tolerance by brook trout. If, for example, midsummer water temperatures had averaged 68-70 degrees F. before the dam was constructed, and if the same increases in water temperature had resulted from the impoundment, the stream very likely would have been reduced to the status of a marginal trout water or would have been lost as trout water entirely.

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Table IV

Comparison of angling quality on Fuller Creek before and after re-installation of the Fuller Creek Dam

Period	Total number of angler-days*	Total hours of angling	Total wild brook trout taken	Catch per hour	Catch per hour per angler	Standard deviation	Standard error	S. E. of difference	t	P
1946-1948	489(82) (16.8%)	692.50	114	0.165	0.166	0.470	0.021	0.031	0.55	41.'
1949-1951	313(69) (22.0%)	712.75	116	0.163	0.149	0.409	0.023			

* Numbers and percentage of successful angler-days are given in parentheses.