FISH POPULATIONS IN BIG SPRING CREEK, MONTANA

by

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A thesis submitted to the Graduate Faculty in partial
fulfillment of the requirements for the degree

of

MASTER OF SCIENCE

in

Fish and Wildlife Management

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MONTANA STATE UNIVERSITY
Bozeman, Montana

June, 1969

VITA

The author, Ronald Gilbert Marcoux, was born in Rochester, New Hampshire, December 18, 1942, to Gideon and Helen Marcoux. He graduated from Edward Little High School, Auburn, Maine in 1960. He served three years with the United States Army from the fall of 1960 to 1963, and was stationed at Baumholder, Germany, in the Signal Corps. He entered the University of Montana, Missoula, Montana, in the fall of 1963 and received a Bachelor of Science degree in Wildlife Technology in June, 1967. He began graduate studies at Montana State University in the fall of 1967 as a Graduate Research Assistant with the Montana Cooperative Fishery Unit. He married the former Sharlee Clarice Holtz of Great Falls, Montana, in June, 1968.

ACKNOWLEDGMENT

The author wishes to extend his appreciation to those who assisted him during the course of the investigation: Dr. Richard J. Graham directed the study, aided in field work, and assisted in preparation of the manuscript; Mr. Richard Johnson of the Montana Fish and Game Department offered many suggestions and aided in the field work; Mr. Richard Vincent provided technical assistance in the shocking technique; Norman Peterson assisted in all aspects of the field work; Dr. William Gould, Neil Martin, Richard Baldes, Ed Nevala, John McCarthy, and other personnel of the Montana Fish and Game Department and Cooperative Fishery Unit aided in the field work; and my wife, Sharlee, assisted in preparation of the manuscript. The investigation was financed by the Montana Cooperative Fishery Unit and the Montana Fish and Game Department under Federal Aid to Fish Restoration Projects F-5-R-18 and F-5-R-19.

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ABSTRACT

Estimates of trout populations, age group I and older, were made in five sections of Big Spring Creek in the summers of 1967 and 1968. A simple mark and recapture method was employed. Combined standing crops of rainbow trout (Salmo gairdneri) and brown trout (Salmo trutta) ranged from 75 to 260 pounds per acre. Rainbow trout predominated and generally comprised over 60% of the total trout populations for all sections. Weighted mean annual survival rates were generally over 0.500 for both species, with higher survival rates generally found for brown trout. Little variation occurred in the growth rate between sections. Recruitment appeared greatest in sections with highest adult populations. Sucker populations, over 8 inches in length, generally increased with progression downstream and attained standing crops over 1000 pounds per acre. With the exception of the most downstream subsection (E), the number of trout per acre positively correlated with the amount of cover 0 to 2 and 2 to 5 feet above the water surface, in the 2000 foot subsections studied in 1968. No apparent correlation existed between trout numbers and cover above 5 feet. A positive correlation also occurred in all subsections, except E, between number of trout per acre and the combined area of aquatic vegetation and submerged cover. Factors beside cover caused the lower standing crop of trout in subsection E.

INTRODUCTION

Big Spring Creek is considered one of the most important trout streams in Central Montana and it is well known for producing large trout. It flows through the city of Lewistown, located 9 miles below the stream's source. Although relatively stable most of the year, the stream has a history of flooding during spring runoff, with five tributaries located upstream from Lewistown contributing much to the greater flow. Because of the flood potential and possible adverse effects to Lewistown, a dam will be constructed on each of the five tributaries (Figure 1). Their primary function will be flood control, but they will also serve as settling basins.

The primary objective of this investigation was to study the trout populations in five sections on Big Spring Creek prior to dam construction and to compare certain physical characteristics and associated trout populations between sections. Field work was carried out during the summers of 1967 and 1968.

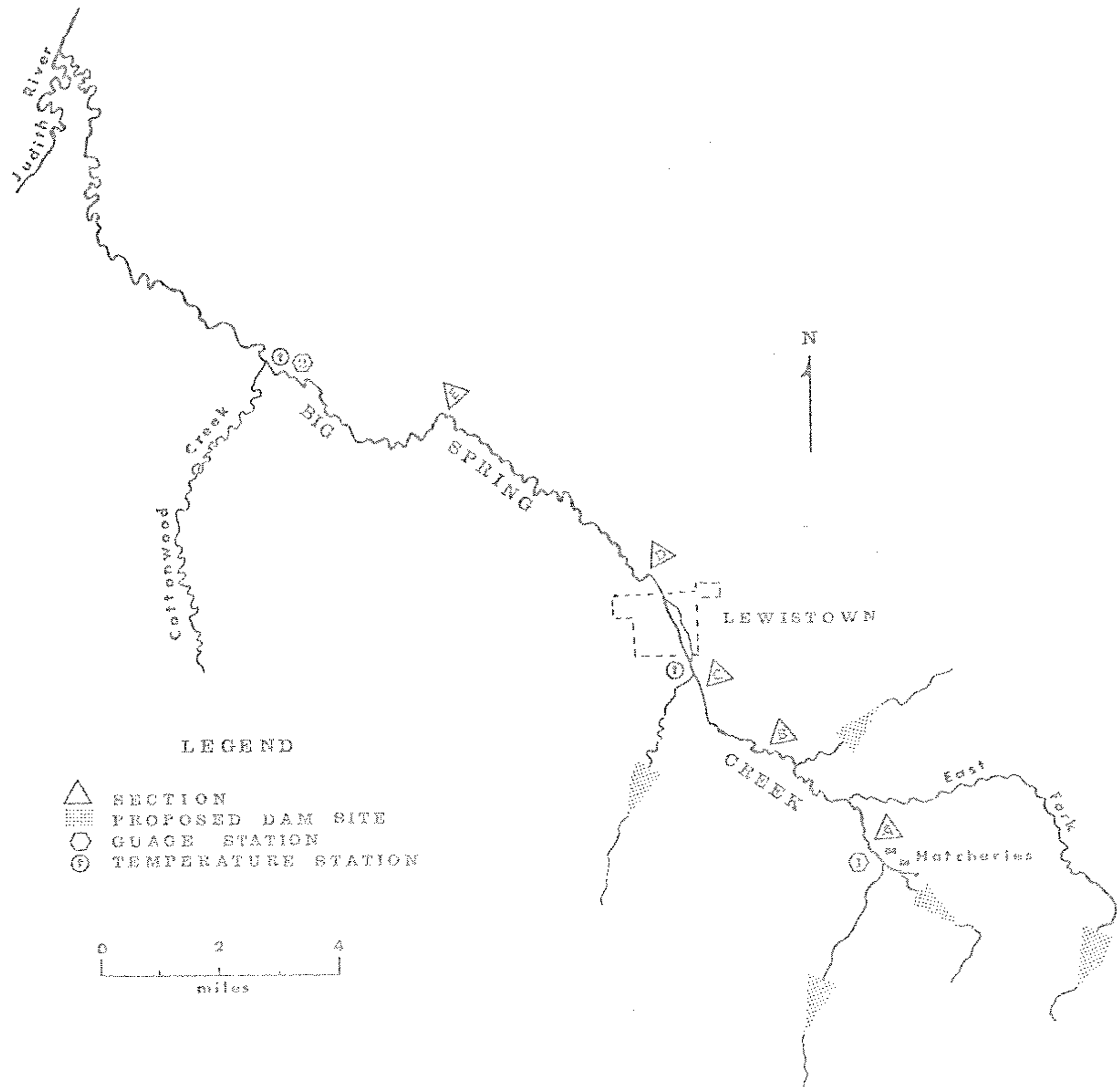

Figure 1. Map of study area, showing location of study sections A through E.

DESCRIPTION OF AREA

Big Spring Creek originates from a series of springs in the foothills of the Snowy Mountains 9 miles SE of Lewistown. It flows NW approximately 35 miles to its confluence with the Judith River. The stream was divided into four areas (Figure 1).

Upstream from Lewistown Area - This encompasses 9 miles between the springs and Lewistown. The stream meanders through a floodplain that averages about 1150 feet in width and has a gradient of 20.5 feet per stream mile. Floodplain soils consist of Twin Creek, Gallatin, and clay loams. Banks are relatively stable, with water birch (*Betula occidentalis*), hawthorne (*Crataegus* spp.), and willow (*Salix* spp.) being the dominant bank vegetation. The bottomland is used primarily for hay production. Two Montana Fish and Game Department trout hatcheries are located within the first 0.5 mile of stream. In 1913, a 4000 foot portion of stream immediately upstream from Lewistown was straightened to facilitate construction of a railroad yard. Permanent homes exist along the stream above the mouth of the East Fork tributary and upstream from the railroad yard, resulting in the removal of much shrubby type bank vegetation.

Lewistown Area - Approximately 3 miles of stream is within the city of Lewistown (pop. 7408). Of this, 0.25 mile flows via a canal located under the main business district. A bypass canal on the eastern edge of the city flows for 0.8 mile to rejoin the stream below the business district. An irrigation ditch intake is located downstream from this junction. Increased urban development and channel alterations have resulted in extensive bank erosion on the stream as it progresses through the northwestern edge of the city. A primary sewage treatment plant with an effluent of 3 to 5 cfs is located about one mile from the city center and is the downstream boundary of this area.

Lewistown to Cottonwood Creek Area - This consists of the 11.5 miles between Lewistown and the mouth of Cottonwood Creek. The floodplain has about the same average width as that upstream from Lewistown but is subject to greater variation. Floodplain soils are composed of Promise clay, Eltsac clay, and shale of the Colorado formation. Twin Creek, Gallatin, and clay loams are also present. Dominant bank vegetation is water birch and willow, frequently interspersed with cultivated grasses in more exposed areas. The bottomland is utilized for the production of hay crops and for cattle grazing. Overgrazing has led to some bank erosion in portions of the first 2 miles of this area, but the remainder is fairly stable. In contrast to the other areas mentioned, only few homes are located near the stream. A short canyon zone is located in the downstream mile of this area.

Cottonwood Creek to Judith River Area - Cottonwood Creek is the main tributary between Lewistown and the Judith River. It contributes little water to Big Spring Creek in periods of low flows but is of consequence during runoff due to a large drainage area. The 11 miles of stream from the confluence of Cottonwood Creek to the Judith River is more unstable than the other areas. Eroded banks and channel migrations are extensive and sediment depositions are greater. The floodplain is little used agriculturally, with only one farm located by the stream. In contrast to other areas, few stream access roads are present.

DESCRIPTION OF STUDY SECTIONS

Five study sections were established on Big Spring Creek. Three were located upstream from Lewistown and two between Lewistown and the confluence of Cottonwood Creek (Figure 1). Section lengths were primarily delineated by stream access points and ranged from 3568 to 5843 feet (Table I). A

TABLE I. Physical characteristics of study sections A through E.

	Section				
	A	B	C	D	E
Length (feet)	3568	5843	3704	4394	5302
Average width (feet)	36.5	43.4	34.2	45.4	44.5 — Av. 40.8'
Area (acres)	2.99	5.82	2.91	4.58	5.42
Sinuosity	1.76	2.10	1.14	1.22	1.29
Average discharge (cfs) 1/	126.6	134.1	143.9	136.9 2/	134.6 2/
Average turbidity (ppm)	14.0	32.2	35.4	45.5	61.5

1/ Measurement in August 1967 and August 1968 only

2/ Measurement obtained only on first of June and July, 1968

total of 13,115 feet was included in the three sections which comprised 27.6% of the total stream length upstream from Lewistown. Section A began 200 yards below the lower trout hatchery and was characterized by abundant aquatic vegetation. Bank cover, composed of water birch and hawthorne, was common on the stream bank, except in the vicinity of a permanent home. The stream bottom ranged from sand to rubble, which was characteristic of most of the sections. Section B was located about 2 miles below the mouth of the East Fork tributary. Section B and other sections below the mouth of this tributary remained turbid for longer periods following runoff, than did section A which had little tributary influence. Bank cover in section B was composed predominately of willow and wild rose (Rosa spp.). Section C included a portion of the straightened area immediately above Lewistown. Major bank cover species were the same as in section B and pools were infrequent compared to other sections.

Two sections totaling 9696 feet were located in the area between Lewistown and Cottonwood Creek. These comprised 16% of the total stream length for this area. Section D began at the outfall of the primary sewage treatment plant. Bank erosion was prevalent in the upper 1000 feet but relatively stable below. Extensive growths of bank willow interspersed with cultivated grasses were present. Section E was located 3.4 miles above the confluence with Cottonwood Creek. Stream banks were well vegetated, primarily with water birch and cultivated grasses. The section appeared typical of that area of stream. Shale and clay were prevalent bottom materials in this section.

Widths taken every 100 feet and averaged for each section, ranged from 34.2 to 45.4 feet (Table I). Sinuosity, the ratio of channel length to down valley distance (Leopold, Wolman, and Miller, 1964), was measured from aerial photos. Only sections A and B were considered meandering, since they had sinuosity values greater than 1.5 (Table I).

Discharge measurements taken with a Gurley current meter in all sections in August of 1967 and 1968 (Table I), showed a progressive downstream increase from sections A to C due to tributary and ground water accretions. The irrigation ditch intake in Lewistown was responsible for slightly lower flows in sections D and E. Flows were comparable between sections in August, but were higher and fluctuated more in the downstream sections during other periods. Discharge measurements were obtained by the U.S.G.S. at two stations nearly every month in 1967 and 1968. Station I was located above section A and Station II was 2 miles below section E (Figure 1). Twenty-two discharge measurements at Station I in 1967 and 1968, ranged from 108 to 250 cfs, but generally remained around 120 cfs. At Station II, 23 discharge measurements ranged from 138 to 1080 cfs and fluctuated around 215 cfs. Lowest flows were in early winter and August at both stations.

Water temperature stations were established 0.5 miles below section C and 2 miles below section E (Figure 1). Thermographs were operated from June to September in 1967 and 1968. Ryan and Taylor thermographs were used in 1967 and only Taylor thermographs were used in 1968. The summer maximum below section C for both years was 68 F and the minimum was 49 F. Maximum temperatures at the downstream station were 69 F and 70 F and minimums were 47 F and 50 F, for 1967 and 1968 respectively. High and low daily temperatures at the downstream station, generally varied less than 3 F from the upstream station. The maximum daily change in temperature reached a high of 14 F at the upstream station and 15 F on the downstream station in 1968. The stream did not become ice-covered in winter.

Forty turbidity readings, measured in Jackson units, were obtained in sections A to C in June and July of 1968. All readings were averaged with the exclusion of those that exceeded 500 ppm during the period of heavy runoff. Section A had the lowest average with sections B and C highest because of the influence of the East Fork. Turbidity readings obtained on all five sections on 1 June and 1 July, 1968, showed a progressive downstream increase. Turbidity readings reduced to zero during the latter portion of July with section A clearing about a week before section B and C.

Total alkalinity, total hardness, pH, and specific conductance were determined within each section on the first of each month from June to September. There was a general increase in all values from section A through section E (Table II).

TABLE II. Range of total alkalinity, total hardness, pH, and conductivity determinations for sections A through E for the period June to September, 1968

Section	Total alkalinity (M.O.) ppm	Total hardness ($CaCO_3$) ppm	pH	Conductivity in reciprocal megohms 25°C
A	130-180	250-290	7.6-7.9	460-525
B	160-200	260-340	7.7-8.4	560-625
C	170-200	280-350	7.7-8.5	560-650
D	180-210	310-370	8.1-8.4	580-660
E	180-220	310-380	8.1-8.6	600-690

Rainbow trout (*Salmo gairdneri*) and brown trout (*Salmo trutta*) were the predominate game fish in the study sections. Mountain whitefish (*Prosopium williamsoni*) and brook trout (*Salvelinus fontinalis*) were also present but generally made up less than 1% of the game fish populations. Other species, in order of decreasing abundance, included the longnose sucker (*Catostomus catostomus*), white sucker (*Catostomus commersoni*), mountain sucker (*Catostomus platyrhynchus*), carp (*Cyprinus carpio*), and northern redhorse (*Moxostoma macrolepidotum*). Carp and northern redhorse were not abundant and occurred only in study sections D and E. The longnose dace (*Rhinichthys cataractae*) and lake chub (*Hybopsis plumbea*) also occurred in study sections D and E, and mottled sculpins (*Cottus bairdi*) were abundant in all sections, but no attempt was made to quantitatively sample these species. "Catchable" rainbow trout were planted in Big Spring Creek prior to and during this study.

METHODS

Fish Populations

Population estimates of wild rainbow and brown trout were made for sections A through E once each year between July 15 and August 20. A mark and recapture method utilizing an initial tagging run followed by a single recapture run was the basis for all estimates. Due to the difficulty of sampling fingerlings (age group 0), only the populations of age group I and older trout were estimated for entire sections. A distinct separation, based on length frequency distribution, occurred between fingerling and yearling trout. Fingerling trout were estimated in July and September of 1967 and in September, 1968, in a 300 foot subsection of section A and a 300 foot section located about one mile below section D. In September, 1968, fingerling estimates were also made for 300 foot subsections within sections B, C, and E.

Trout were captured utilizing a variable voltage, pulsed D.C. (half-wave rectified A.C.) generator. These were anesthetized with MS-222 (Tricane Methanesulfonate), measured to the nearest 0.1 inch in total length, and weighed to the nearest 0.01 pound. Plastic dart tags were used to mark trout over 8 inches and a partial caudal clip was used on trout from 4 to 8 inches in 1967. An intracutaneous injection in the lower jaw with National Fast Blue 8GXM dye (Kelly, 1967), was used to mark trout over 4 inches in 1968. Fingerling trout were marked with a partial caudal clip. Rainbow trout planted in Big Spring Creek in 1967 and 1968 had the adipose fin removed for identification.

Scales were collected from 1114 trout in 1967 and 889 trout in 1968. An attempt was made to get at least 15 scale samples for each inch-group. Lengths at all annuli were determined with a nomograph, assuming a linear relationship between scale and body growth.

In 1967, population estimates were attempted on all sections using 1-inch, 2-inch, and age-group intervals. In 1968, only age-group intervals were used. Estimates were calculated using the Bailey modification of the Petersen estimator (formula 3.7 in Ricker, 1958).

Scale analyses were used to delineate size groups for the age-group method. Two types were delineated, those that contained a single age group and those that included age group overlap areas. Estimates using age-group intervals, were determined by estimating size groups which contained a single age group and then estimating separately the size groups which contained areas of overlap. Estimates of fingerling and yearling trout were made for 1.0 or 1.5 inch intervals within the size group where a single age group was present to compensate for the lower shocking efficiency for trout under 7 inches (Cooper and Lagler, 1956). Frequently age groups III and older, would have no distinct size group containing a single age group. In such cases, estimates were made in size-group intervals of 2 inches, unless the sample size was so small as to necessitate extention of this interval. The percent of each age group within each size group of an overlap area was determined from scale analyses. Trout in age group V or older were placed in V+.

The populations of longnose sucker and white sucker were estimated separately using the same methods as for trout, although a partial fin clip and caudal punch were used for marking. Estimates were made for the entire length of sections A through C in 1967 and 1968, the first 2235 feet of section D for both years, and the initial 1769 feet of section E in 1968. In 1967, suckers were grouped into two size intervals, 8 to 12 inches and over 12 inches, while only one interval, 8 inches and above, was used in 1968.

Confidence intervals at the 95% level were computed for the total rainbow trout, brown trout, and sucker estimates, using formula 6 of the Michigan Institute for Fisheries Research (1960), and pooling the variance for each size interval estimated.

Annual and weighted mean annual survival rates for trout age group I through V+ were calculated according to formula 2.1 and 2.2, respectively, in Ricker (1958).

Subsection Morphology, Cover, and Trout Populations

In 1968, 2000 foot subsections were selected from a representative portion of each section for studies of cover, morphology, and trout relationships. These were located at the head of sections A through C, the last 2000 feet of section D, and 1000 feet below the beginning of section E. Transects perpendicular to the stream flow were placed at 50 foot intervals. Depths were taken at 2 foot intervals across the stream at each transect, and depth measurements 1 foot and 3 feet from each bank or the waters edge were also obtained. Measurements were made in August and early September during the period of lowest flows.

The cover area was measured for 3 feet on each side of a transect on both banks to the nearest 0.5 square foot. Cover included shrubs, debris, such as dead snags and branches, grasses and rocks. It was classified as submerged, or as to height above the water surface with distinctions from 0 to 2, 2 to 5, 5 to 10, and 10 feet or over. Aquatic vegetation, classified separately, was measured whenever encountered within 3 feet of a transect. The area of each cover classification for a subsection was computed by totaling the cover area of each classification from the 40 transects.

Population estimates of rainbow and brown trout, age group I and older, were obtained for each subsection in 1968, at the same time as the section estimates. Methods previously explained were used.

RESULTS

Trout Populations - 1967 and 1968

A comparison of population estimates and age group separation using 1-inch size intervals, 2-inch size intervals, and age-group intervals, was made on the rainbow and brown trout in sections A and D in 1967 (Table III).

TABLE III. Total population estimates and numbers per age group of rainbow and brown trout from sections A and D in 1967. (95% confidence interval in parentheses).

	Age Group					
	I	II	III	IV	V+	Total
Rainbow trout						
Section						
A						
1-inch interval	813	412	200	19	3	1447 (± 201)
2-inch interval	744	442	190	17	4	1397 (± 186)
Age-group interval	804	401	190	18	4	1417 (± 218)
D						
1-inch interval	656	366	222	99	3	1346 (± 278)
2-inch interval	642	375	219	102	3	1341 (± 268)
Age-group interval	632	404	214	105	6	1361 (± 280)
Brown trout						
Section						
A						
1-inch interval[1/]	---	---	---	---	-	----
2-inch interval	46	63	30	18	30	187 (± 37)
Age-group interval	41	62	31	14	35	183 (± 34)
D						
1-inch interval	138	255	100	48	8	549 (± 154)
2-inch interval	138	266	98	47	8	557 (± 154)
Age-group interval	138	261	78	55	6	538 (± 102)

1/ Sample size too small for valid estimate with this method.

Other sections had too few trout to make valid estimates using the 1-inch interval. There was little difference between estimated totals or numbers per age group. The age-group method gave more flexibility in grouping size intervals where recapture samples were small. This eliminated some negative bias which occurs when the product of the marked sample and subsequent recapture sample does not exceed at least three times the population size (Robson and Regier, 1964). Negative bias would have occurred frequently if the 1-inch size intervals were used. Less error was evident by the age-group method when separating age groups, particularly when the overlap was large and scale samples few, as occurred frequently with brown trout populations. The 1-inch and 2-inch interval methods would often break within overlap areas, requiring a double proportioning of age groups from these, and increasing the potential for error. The age-group method was most satisfactory and was used for all estimates.

Total population number, as well as number and pounds per acre were computed for section A through E (Table IV). Rainbow trout was the most abundant species in 1967, comprising 59.4 to 88.6% of the total number of trout per acre, and 53.1 to 62.8% of the total pounds per acre. The greatest number and pounds per acre of rainbow trout were in section A. Section D had the largest number of brown trout per acre, but section A had the most pounds per acre, due to several exceptionally large brown trout. The numerical ratio of brown trout to rainbow trout increased progressively downstream in 1967. The number and pounds per acre of both species was highest in sections A and D, intermediate in B and C, and lowest in section E.

TABLE IV. Population estimates of rainbow and brown trout, age group I and older, for sections A through E in 1967 and 1968. (Pounds per acre in parenthesis).

	SECTION				
	A (2.99 A)	B	C	D	E
1967					
Rainbow trout					
Total per section	1417	811	668	1361	311
95% confidence interval	1216-1618	735-887	470-866	1081-1641	203-419
Number per acre	474 (138)	139 (63)	230 (58)	297 (98)	57 (46)
Brown trout					
Total per section	183	273	153	538	208
95% confidence interval	149-217	209-337	105-201	436-640	156-260
Number per acre	61 (122)	47 (45)	53 (46)	118 (58)	39 (29)
Total trout					
Number per acre	535 (260)	186 (108)	283 (104)	415 (156)	96 (75)
1968					
Rainbow trout					
Total per section	1491	784	459	1059	295
95% confidence interval	1317-1665	604-964	363-555	737-1381	223-367
Number per acre	499 (109)	135 (66)	158 (69)	231 (94)	54 (46)
Brown trout					
Total per section	163	182	104	426	282
95% confidence interval	127-199	130-234	72-136	298-554	178-386
Number per acre	55 (66)	31 (30)	36 (32)	93 (51)	52 (34)
Total trout					
Number per acre	554 (175)	166 (96)	194 (101)	324 (145)	106 (80)

The proportion of rainbow trout in 1968 remained about the same as 1967. The number of rainbow trout per acre decreased in 1968 in all sections, except A, and the number of brown trout in all sections, except E. The numerical ratio of brown trout to rainbow trout remained similar to 1967, with the ratio in section E showing the greatest change (8.5% increase). With the exception of section A, which decreased 85 pounds, the pounds per acre of combined trout changed only slightly between 1967 and 1968. The ranking of sections based on number and pounds per acre of both species combined remained the same as 1967.

Total number and pounds of rainbow and brown trout in each age group were computed for all sections (Table V). Yearlings contributed 41.7 to 70.0% of the total number and 8.8 to 29.4% of the total weight of rainbow trout in sections A through D in 1967. In section E, yearlings contributed only 15.8% of the total number and 6.0% of the total weight. Most of the total weight of rainbow trout came from age groups II and III in sections A through C and age groups III and IV in sections D and E in 1967. In 1968, yearlings contributed 28.7 to 68.8% of the total number and 10.7 to 29.3% of the total weight of rainbow trout, which was similar to the previous year. Yearling rainbow trout increased only in section A in 1968, with decreases in all other sections. Most of the total weight came from age groups II and III in all sections in 1968. In 1967, each successively older age group in sections A through D, decreased in abundance. In 1968, with the exception of section A, the number of age group II rainbow trout exceeded the number of yearlings, indicating recruitment or survival of

TABLE V. Total number of brown and rainbow trout per age group for sections A through E in 1967 and 1968. (Total pounds in parentheses).

		Age Group				
		I	II	III	IV	V+
Rainbow trout						
1967	Section					
	A	804 (76)	401 (152)	190 (133)	18 (25)	4 (27)
	B	338 (32)	243 (133)	183 (153)	47 (47)	0 (0)
	C	468 (50)	119 (52)	68 (55)	13 (13)	0 (0)
	D	632 (15)	404 (94)	214 (158)	105 (117)	6 (7)
	E	49 (15)	110 (44)	66 (52)	59 (91)	27 (47)
1968						
	A	1026 (96)	306 (111)	150 (96)	5 (6)	4 (19)
	B	225 (41)	338 (156)	209 (150)	12 (36)	0 (0)
	C	157 (33)	245 (116)	45 (39)	12 (12)	0 (0)
	D	333 (70)	503 (194)	184 (127)	39 (41)	0 (0)
	E	0 (0)	122 (97)	144 (111)	29 (43)	0 (0)
Brown trout						
1967	Section					
	A	41 (8)	62 (28)	31 (29)	14 (22)	35 (277)
	B	32 (5)	51 (22)	105 (93)	69 (98)	16 (47)
	C	14 (3)	35 (14)	52 (51)	50 (63)	2 (4)
	D	138 (27)	261 (97)	78 (56)	55 (69)	6 (16)
	E	95 (30)	60 (55)	44 (58)	9 (16)	0 (0)
1968						
	A	37 (8)	55 (31)	36 (36)	23 (33)	12 (83)
	B	19 (8)	26 (12)	61 (50)	76 (98)	1 (7)
	C	8 (3)	16 (10)	40 (36)	40 (46)	0 (0)
	D	100 (20)	208 (82)	83 (79)	35 (53)	0 (0)
	E	109 (30)	88 (46)	39 (40)	39 (58)	7 (11)

fingerlings in 1967 was not as good as 1966 for sections B through E. The reproduction or survival of fingerling rainbow trout in section E was extremely low, as indicated by the number of yearlings in relation to older fish in 1967 and 1968. The older rainbow trout may have moved into this section or were survivors of stronger year classes.

Yearlings comprised from 9.1 to 22.4% of the total number and 1.9 to 2.2% of the total brown trout weight in sections A through C and 25.7 to 45.9% of the total number and 10.2 to 18.9% of the total weight in sections D and E, respectively, in 1967. Most brown trout were in age groups III and IV in sections B and C and age groups I and II in sections A, D, and E, in 1967. The greatest weights came from age groups III and IV in sections B and C and usually from age groups II and III in sections D and E. Age group V+ in section A, comprised 76.1% of the total weight due to a number of exceptionally heavy trout, averaging 9 pounds (range 6 to 16 pounds). The number and weight percentages of yearling brown trout in 1968 were about the same as 1967. Although a general decrease occurred in all sections except E in 1968, the highest numbers and weights were generally found in the same age groups as 1967. Brown trout of age group V+ weighed 194 pounds less in 1968 than in 1967 and accounted for a large portion of the decrease in pounds per acre of all trout in section A.

Annual survival rates were computed for rainbow and brown trout, age group I through V+, in all study sections for the period August, 1967, to August, 1968 (Table VI). Survival rates were variable between sections and between species. Brown trout survival was generally higher than reported by Mcfadden and Cooper (1962), who used only a single estimate of the population. With the exception of rainbow trout in section A, the survival rates found in my study for both rainbow and brown trout are generally higher than those reported in the literature. Lower survival rates of rainbow trout from section A, may result from emigration, cannabalism, or

TABLE VI. Annual and weighted mean annual survival rates for rainbow and brown trout in sections A through E from August, 1967 to August, 1968. (Computed from Table V).

	Age Group				
	I-II	II-III	III-IV	IV-V+	Weighted Mean I-V+
Rainbow trout					
Section					
A	0.381	0.374	0.026	0.222	0.335
B	1.000	0.860	0.066	0.000	0.689
C	0.523	0.378	0.176	0.000	0.452
D	0.796	0.455	0.182	0.000	0.536
E	2.489	1.309	0.439	0.000	1.073
Brown trout					
A	1.341	0.571	0.766	0.667	0.851
B	0.813	1.196	0.724	0.000	0.638
C	1.142	1.142	0.769	0.000	0.636
D	1.507	0.318	0.449	0.000	0.613
E	0.926	0.650	0.866	0.777	0.832

fishing mortality. Several age groups of rainbow and brown trout had survival rates over 1.000, possibly due to immigration into the study sections. Horton (1959) reported immigration of two to four year old brown trout into his study areas. Immigration from tributaries was the cause of cutthroat trout showing an increase with time (Lowry, 1966).

Because the number of trout in older age groups is generally less than younger age groups, the survival rates of older age groups are considered less reliable (Ricker, 1958). A better comparison results by estimating a weighted mean annual survival rate (Jackson, 1939), which removes aberrations caused by age grouping or sampling. The weighted mean annual survival rates for age groups I through V+ from August, 1967, to August, 1968, were also higher for brown trout than was reported by Mcfadden and Cooper (1962). Their study and literature review showed mean annual survival rates to be usually less than 0.500.

The average growth rate of rainbow and brown trout was determined for each section in 1967 and 1968 (Table VII). Little differential growth rate was observed between sections, with the exception that average lengths were slightly higher in section E, where scales showed numerous check marks. Analyses of scales from trout, age group IV and older, were difficult because of the large number of partially eroded or regenerate scales encountered.

In 1968, the abundance of fingerling trout in the 300 foot subsections (Table VIII), corresponds to the abundance of older trout in respective sections. Rainbow trout fingerlings were predominate in subsections A through C, while brown trout were most abundant in subsections D and E. From late July to September, 1967, a decrease of 74.8% occurred in the fingerling rainbow trout from subsection A, and a decrease of 51.5% occurred in the brown trout from subsection D. High decreases of fingerling brown trout and brook trout during the first few months of life were reported by Allen (1951) and Mcfadden (1961), respectively, and were attributed to high mortality.

A total of 2,053 trout were tagged with dart tags in 1967, to evaluate movement, fish growth, and fisherman harvest. From recaptured trout in 1968, a tag loss of 72.6% was indicated by the ratio of tagged trout to those with identifiable scars in the area of tag application. This loss

TABLE VII. Average calculated total lengths at each annulus for rainbow and brown trout in sections A through E.

	Section	Length at Annulus I	II	III	IV	V
Rainbow trout						
1967	A	4.1 (140)[1/]	7.8 (89)	11.1 (37)	14.2 (8)	20.3 (1)
	B	4.3 (81)	8.4 (48)	11.0 (27)	13.3 (5)	----
	C	4.3 (64)	8.0 (33)	11.8 (6)	14.2 (1)	----
	D	4.4 (134)	7.7 (94)	10.9 (51)	13.2 (16)	14.9 (1)
	E	4.6 (121)	9.9 (90)	11.2 (70)	13.8 (43)	15.5 (14)
1968	A	4.2 (121)	7.4 (88)	10.8 (31)	14.2 (5)	19.6 (1)
	B	4.4 (86)	8.1 (61)	11.7 (26)	13.2 (2)	----
	C	4.5 (133)	7.7 (97)	10.9 (11)	13.0 (3)	----
	D	4.4 (62)	7.9 (48)	10.5 (17)	13.1 (2)	----
	E	5.6 (68)	8.8 (68)	11.7 (24)	14.6 (7)	----
Brown trout						
1967	A	4.6 (66)	8.0 (50)	11.9 (23)	14.8 (9)	18.1 (3)
	B	4.5 (87)	8.3 (68)	12.1 (57)	15.2 (24)	19.1 (6)
	C	4.7 (33)	8.2 (26)	11.6 (18)	14.2 (11)	15.9 (1)
	D	4.8 (106)	8.5 (89)	11.7 (38)	14.3 (16)	18.3 (2)
	E	5.6 (108)	10.7 (57)	13.7 (23)	16.6 (4)	----
1968	A[2/]	4.8 (56)	8.2 (46)	11.9 (26)	14.8 (16)	18.5 (6)
	B[2/]	4.7 (50)	8.1 (41)	11.3 (29)	13.8 (13)	----
	C	----	----	----	----	----
	D	4.6 (72)	8.2 (48)	11.8 (14)	14.2 (2)	----
	E	5.4 (49)	8.4 (26)	11.9 (13)	14.5 (3)	15.8 (3)

1/ Number of fish in sample

2/ Grouped in 1968

TABLE VIII. Estimated fingerling (age group 0) rainbow and brown trout populations for 300 foot subsections. (95% confidence interval in parentheses).

	Subsection				
	A	B	C	D 1/	E
July - 1967					
Rainbow trout	512 (107-917)	--	--	16 (7-25)	--
Brown trout	17 (8-26)	--	--	97 (59-135)	--
September - 1967					
Rainbow trout	129 (83-175)	--	--	9 (6-12)	--
Brown trout	20 (7-33)	--	--	47 (33-61)	--
September - 1968					
Rainbow trout	180 (115-245)	62 (24-100)	30 (5-55)	4 (0-8)	1 --
Brown trout	23 (7-39)	3 (1-5)	20 (0-45)	120 (49-191)	20 (7-33)

1/ Located 1 mile below section D.

agrees with Nelson (1960), who found a tag loss of 73% over a four month period under hatchery conditions. Nelson observed algal growth accumulating on the tags, which also occurred in my study and was believed to be a major factor in causing tag loss.

Fishermen returned 67 (3.3%) of the total number of tags applied in 1967. The returns came generally from the vicinity where the trout had been tagged. Tagged trout recaptured during the 1968 sampling, were found in the same sections where tagged.

Of 106 recaptured trout in 1968 that retained tags, 48 (45.3%) had grown less than 0.5 inches the preceding year. It appeared that the dart tags had a detrimental effect on the growth of trout retaining tags. Nelson (1960) suggested growth rate may have been adversely affected by dart tags, but because of high tag loss, could draw no definite conclusion.

Sucker Populations

The abundance of suckers over 8 inches in length, generally increased progressively downstream (Table IX). Populations were sparse in section A, intermediate in sections B and C, and very abundant in D and E. With the exception of section A in 1968, the longnose sucker predominated both in number and weight. Although only portions of sections D and E were sampled, suckers appeared to be in comparable abundance in the remainder of respective sections. The standing crops of suckers in sections D and E were considerably higher than those previously reported for other trout streams. Elser (1968) in Montana, and Mcfadden and Cooper (1962) in Pennsylvania, reported standing crops as high as 273 and 373 pounds per acre, respectively. Gunderson (1968) found less than 30 pounds per acre in Rock Creek, Montana.

TABLE IX. Population estimates of suckers over 8 inches in length, in 1967 and 1968. (Pounds per acre in parentheses).

	SECTION				
	A	B	C	D[1]	E[1]
1967					
Longnose sucker					
Total per section	13	865	464	2781	no estimate
95% confidence interval	11-15	476-1254	238-690	1343-4219	
Number per acre	4(2)	149(214)	160(224)	1194(1315)	
White sucker					
Total per section	2	347	169	169	no estimate
95% confidence interval	2-2	177-517	114-224	84-254	
Number per acre	1(1)	60(45)	58(41)	73(44)	
Total number per acre	5(3)	209(259)	218(265)	1267(1359)	
1968					
Longnose sucker					
Total per section	3	817	576	2080	3074
95% confidence interval	3-3	440-1194	235-917	568-3592	1499-4649
Number per acre	1(1)	140(190)	198(259)	893(1098)	1698(2191)
White sucker					
Total per section	8	268	142	173	150
95% confidence interval	6-10	162-374	53-231	62-284	30-270
Number per acre	3(2)	46(38)	49(34)	74(49)	83(80)
Total number per acre	4(3)	186(228)	147(293)	967(1137)	1781(2271)

1/ Estimates were based on 50.9 and 33.4% of the total length of sections D and E, respectively.

Subsection Morphology, Cover, and Trout Populations

Average widths, ranged from 34.2 feet in subsection C, the altered section, to 47.1 in subsection E (Table X). Average depths, ranged from 1.33 feet in subsection A to 2.02 feet in subsection C. There appeared to be no correlation between average depths at 1 foot and 3 feet from the bank and trout populations.

TABLE X. Morphological characteristics of subsections A through E in 1968.

Section	Average width (feet)	Average depth (feet)	Average depth from bank (feet) 1 foot	3 feet	Area (acres)
A	37.3	1.33	0.60	0.79	1.71
B	40.8	1.80	1.10	1.29	1.87
C	34.2	2.02	0.70	1.03	1.57
D	37.7	1.59	1.19	1.36	1.73
E	47.1	1.74	0.98	1.17	2.16

Dominant cover species were hawthorne and water birch comprising 58.2 and 14.3% respectively, of the total overhanging cover in subsection A. Willow comprised 64.2, 52.7, and 89.1% of the total overhanging cover in subsections B through D, respectively. Wild rose provided a high percentage of the remaining cover in subsections B and C. Subsection E had water birch and grasses comprising 58.5 and 12.5%, respectively, of the overhanging cover. Debris provided the majority of submerged cover in all subsections. Aquatic vegetation was predominately watercress (Nasturtium officinale) and speedwell (Veronica americana), which formed mats in quieter water, and threadleaf pondweed (Potamogeton filiformis) and water buttercup (Ranunculus aquatilis), which was locally abundant in faster water. Bridges in subsections C and E comprised 111 and 162 square feet, respectively, of the cover area from 5 to 10 feet, but were not considered overhanging cover in the previous discussion.

Submerged cover was greatest in subsections D and E, and least in subsections A and C (Table XI). Cover from 0 to 2 feet and 2 to 5 feet above the surface was most abundant in subsections A and E. Subsections B through D were similar to each other in these categories, although subsection D was somewhat higher in the 2 to 5 foot category. Subsections A, C, and E, had the most cover over 5 feet in contrast to subsections B and D. Aquatic vegetation was abundant only in subsection A.

TABLE XI. The area (square feet) for each classification of cover in subsections A through E, as measured from 40 transects per subsection.

Section	Submerged cover	Cover above the water surface				Aquatic vegetation
		0 to 2 feet	2 to 5 feet	5 to 10 feet	over 10 feet	
A	62.0	760.6	624.5	343.5	126.0	381.5
B	104.3	560.0	241.4	42.0	0.0	6.0
C	16.0	600.2	229.2	172.8 1/	120.0	1.0
D	334.4	614.8	360.4	23.0 1/	0.0	0.0
E	298.2	714.8	792.4	516.0	24.0	27.0

1/ Bridges comprised 111 and 162 square feet of cover in subsections C and E, respectively.

Trout population estimates in subsections (Table XII), showed slight differences in numbers and pounds per acre in comparison to total section estimates, but the ranking of subsections in terms of trout abundance remained the same. Subsections A and D had the largest populations, B and C intermediate, and subsection E the lowest.

TABLE XII. Population estimates of rainbow and brown trout, age group I and older, for the 2000 foot subsections within sections A through E in 1968. (Pounds per acre in parentheses).

	Subsection				
	A	B	C	D	E
Rainbow trout					
Total number	871	203	201	401	71
95% confidence interval	755-987	136-270	150-252	199-603	17-125
Number per acre	509 (103)	109 (51)	128 (56)	232 (77)	33 (29)
Brown trout					
Total number	71	46	32	233	95
95% confidence interval	53-89	26-66	23-41	147-319	49-141
Number per acre	42 (50)	25 (21)	21 (18)	135 (70)	44 (29)
Total trout					
Number per acre	551 (153)	135 (72)	149 (74)	367 (147)	77 (58)

The relationship between number of trout per acre and cover area is shown in Figure 2. With the exception of subsection E, subsections with higher amounts of cover in the categories from 0 to 5 feet above the surface, had higher trout populations, with the best correlation for the 2 to 5 foot category. Subsection A had little submerged cover, but had the greatest amount of aquatic vegetation, which constitutes an important type of cover (Boussu, 1954). A positive correlation was found for all subsections, except E, when the amounts of submerged cover and aquatic vegetation were combined and compared to the number of trout per acre. There was no consistent relationship between subsection trout populations and cover from 5 to 10 feet or over 10 feet. Although subsection E had a great amount of cover, it had the smallest population of trout.

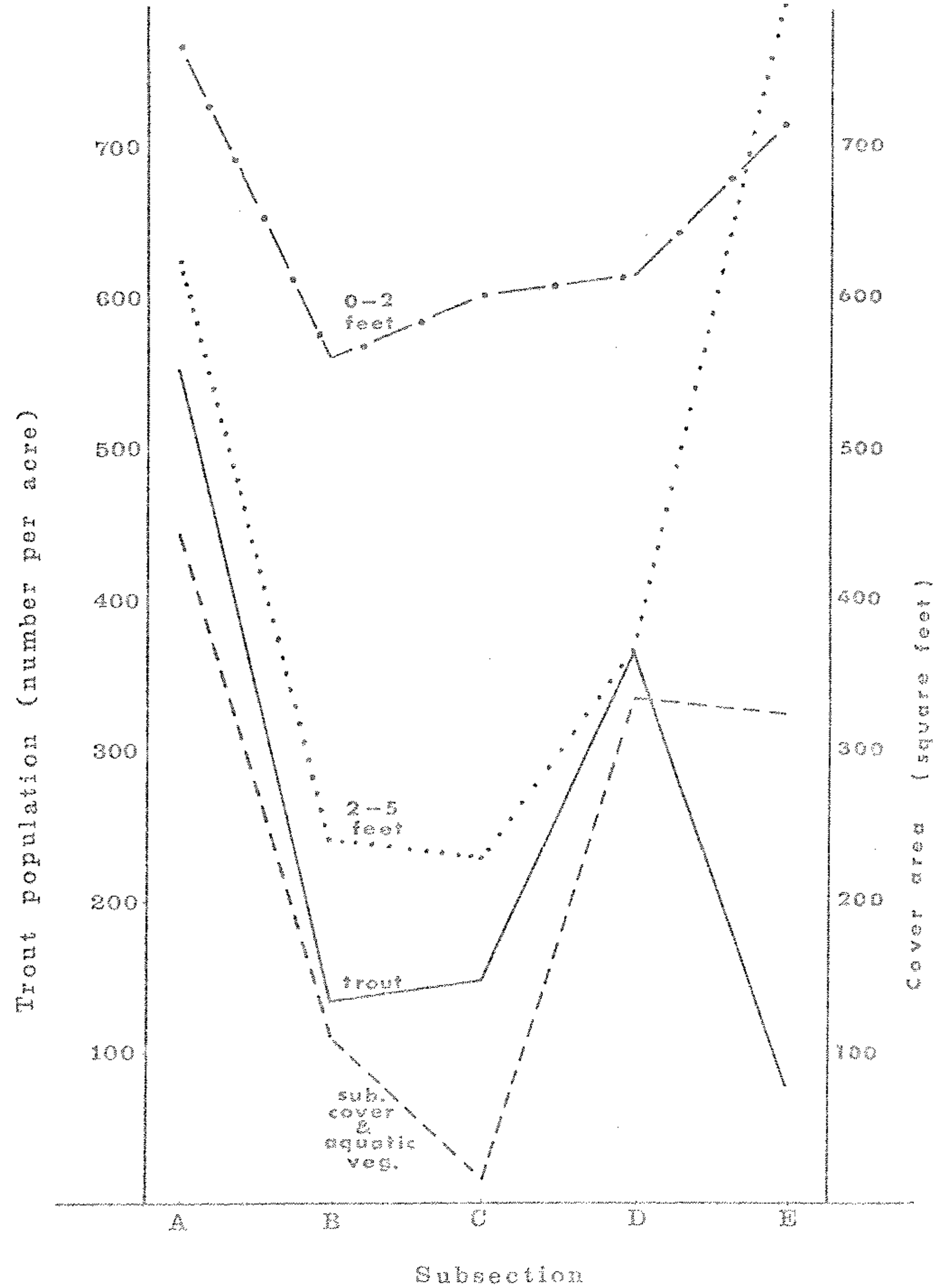

Figure 2. Relationship of subsection trout populations to cover above the water surface and combined cover below.

DISCUSSION

Estimated standing crops of trout from 58 to 260 pounds per acre in this study are comparable to those reported for other streams in Montana. Elser (1968) found 40 to 226 pounds per acre from mixed populations of rainbow, brown, and brook trout in Prickley Pear Creek. Vincent (1968) reported combined rainbow and brown trout populations estimated in June from the East Gallatin River ranged from 97 to 180 pounds per acre. Gunderson (1968) studied disturbed and undisturbed portions of Rock Creek and found brown trout populations of 114 and 151 pounds per acre, respectively.

Trout survival rates are known to fluctuate between years and between streams. Such factors as emigration, immigration, dominance and cannabalism by older trout, environmental changes, and differential recruitment may account for fluctuations. Fishermen harvest may affect survival rates of older trout. Needham, Moffet, and Slater (1945) reported standing crops of 297 and 69 pounds per acre of brown trout in an unfished and fished section, respectively, in Convict Creek, California, although short sections and cover variation between sections may have had some effect on the results. In the Horokiwi stream in New Zealand, Allen (1951) estimated survival of brown trout as 0.28 before and 0.17 after the trout were large enough to crop. Mcfadden (1961) found that heavy exploitation of age group II brook trout in Lawrence Creek, Wisconsin, accounted for the scarcity of older trout. The higher survival rates for trout in this study may be an indication of low harvest by fishermen. Section A had the greater fishing pressure of any section during this study and rainbow trout had the lowest mean annual survival rate in this section. Brown trout still had high survival rates but this may have been caused by differential catchability in comparison to rainbow trout.

Trout populations in streams have been shown to be related to the amount of cover present by several workers (Boussu, 1954; Saunders and Smith, 1962; Elser, 1968; Gunderson, 1968). In my study, cover apparently contributed to the population differences between all sections except E. Other factors known to influence trout populations were not measured. Current velocity was found to be an important factor in determining the abundance of trout in various pools of Prickley Pear Creek, Montana (Lewis, 1969). Enrichment from the trout hatcheries and sewage outflow may have increased food production in sections A and D and contributed to the larger trout population. High sediment loads and erratic discharge were related to high rough fish populations, low trout populations, and high trout embryo mortality on Bluewater Creek, Montana (Peters, 1967). The higher turbidities and greater discharge fluctuations below the East Fork may have had an influence on sections B through E, since sucker populations were much higher and trout populations and reproduction generally lower than in section A, which was not so greatly affected by these factors.

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