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April 16, 2009

Carol Endicott
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Dear Carol,

Enclosed is the 1984 report on my investigations in East Fork of Duck Creek. I just found it recently. The information is much more detailed than what I dug up for you before.

Note that Table 1 shows the exact channel lengths of each study station and describes the station marker positions. Many of those landmarks undoubtedly have disappeared, and channel changes may have occurred, but the key reference points, the upper and lower ends of the Sioux Crossing road culvert probably still exist (or can be closely estimated). Therefore, you may be able to find and sample the same stations (lengths of channel) that my crew did.

Also, my recollection is (and you can check the report on this) that our extensive, efficient, and repeated electrofishing in this stream never captured any fish except cutthroat and brown trout. I remember this stream as the only one among dozens (probably scores) that I have similarly sampled in various states, where trout were the only fishes.

Please get in touch with me if you have questions. Best of luck with your project. I am greatly interested in perpetuation of wild Yellowstone cutthroat trout populations. Sometime when I'm back in the area (perhaps next fall), it would be great to visit the creek with you or other project staff—and to hear how things are working out.

Sincerely,

Ray J. White

Ray J. White

TROUT POPULATIONS AND HABITAT IN THE SIOUX CROSSING AREA OF THE EAST FORK OF DUCK CREEK, MONTANA

OCTOBER-NOVEMBER 1983

A report to
Mr. and Mrs. Whitney MacMillan

by

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Date of Report: March 1984

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INTRODUCTION

At your request, Trout Habitat Specialists investigated trout populations and habitat in the Sioux Crossing area of the East Fork of Duck Creek, Sweetgrass County, Montana, in October and November, 1983. The objectives were:

1. To analyse trout population characteristics.

2. To analyse habitat problems and potentials.

3. To develop recommendations on courses of action for habitat management (and other management).

STUDY SITE AND METHODS

Description of the Site and Conditions during Study

The East Fork of Duck Creek drains a portion of the south face of the Crazy Mountains in Sweetgrass County. It joins the West Fork of Duck Creek to form Duck Creek which is tributary to the Yellowstone River near the village of Springdale. In terms of very rough stream distances, the study section (sec 4 of T1N-R12E and sec 33 of T2N-R12E) lies 11-13 km (7-8 mi) below the creek's headwaters, about 16 km (10 mi) above its confluence with the West Fork, and about 24 km (15 mi) upstream from the Yellowstone River.

The 1.17-km (0.73-mi) section of stream studied, is essentially a small canyon creek in lightly grazed riparian woodland, densely thicketed with willow brush in some areas which contain beaver colonies, and with well-developed stands of cottonwood in other areas. The study section extended from a point 446 m (0.28 mi) by stream distance above the Sioux Crossing road culvert to a large beaver dam located 714 m (0.44 mi) below the road. This was the lowermost of the series of beaver dams in the lower third of the study area. There were no beaver dams above the road. Within the 1.17-km study section, all but 10 m of road culvert and 17 m of a log-jam area was electrofished.

The study section was divided into 15 subsections, called "stations." The divisions were made according to apparent breaks in habitat type and at major obstacles in the stream channel, such as high log jams or beaver dams (Tables 1 and 2). Station lengths ranged from 31 to 174 m. (The 31-m station was a combination of the two impractically short stations, 13 and 14, the lengths of which resulted from logistical problems during electrofishing.)

In stations 3 and 4 (Tables 1 and 2), the creek has two channels. The flow appears to have split rather recently due to disintegration of an abandoned beaver dam which forms the lower boundary of station 5. About half the stream continues to flow in the main channel on the northeast side of the valley floor, the rest along the other side of the valley, rejoining near the lower end of station 3. We studied only the main channel. Much good habitat and many trout undoubtedly exist in the new, ill-defined channel which flows rather sluggishly through an almost impenetrable and virtually unfishable jungle of willow.

The study took place during a baseflow period in which stream discharge was probably near this year's late-summer low. However, flow during the study period may have been somewhat greater than the low of most other years, due to above-average rainfall during summer and fall of 1983 (U.S. Dept. of Commerce 1983, 1984). Measured streamflow discharge on 26 November 1983 at Sioux Crossing was 30 liters/sec (1.1 cubic ft/sec), which I regard as a "low estimate" due to probable instrument error (see Habitat Measurements section, below).

Fish Population Inventory

The major investigational operation was a fish population inventory by electrofishing. This constituted a foot-by-foot examination of the trout population in association with its habitat throughout the study area. The electrofishing began at the lowest large beaver dam, 714 stream meters below Sioux Crossing, and progressed upstream.

Electrofishing was done with a 240-volt AC alternator, the current rectified to 150-250 DC by a control unit. We used 2 positive electrodes in most of the creek, only one in narrow areas. The equipment was pulled upstream in a canoe through most of the study section, but some of the uppermost stations were electrofished with a long extension cord attached to the same unit.

The trout population data shown or referred to in all tables, figures and discussion of this report are, unless labeled otherwise, refer to STATISTICAL ESTIMATES OF ACTUAL ABUNDANCE, NOT JUST THE NUMBERS CAUGHT. For most purposes, the simple catch would not accurately represent the true population. Electrofishing usually is far from efficient enough to capture all fish present and tends to catch a higher proportion of the larger ones, which are more susceptible to the electrical field and to being seen and netted by the operators. The procedures described below measure efficiency of the sampling and adjust the catch data within narrow strata of the body size distribution, minimizing selectivity bias.

Stations 1-13

A standard two-run mark-and-recapture procedure was used in stations 1-13 (first run October 7-8; second run October 14-15). Each fish captured was anesthetized (tricaine methanesulfonate), measured to the nearest millimeter of length, and weighed to the nearest gram--except that only a small sample of lengths was taken for the age-0 cutthroat trout (33-62 mm), and we weighed few fish less than 100 mm in length. Scales were taken from a sample of fish for possible later age analysis (not included in this study).

The calculation of population estimates was by a modified Petersen method (Ricker 1975, page 78), stratified for each species by 2-cm length groups--except in the case of age-0 fish, which were treated as a single size group within each species. Biomass for each species was calculated by summing the products of the population estimate and mean weight of each length group. Mean length-group weight was taken from graphed curves of the length-weight relationships (Figures 3 and 4).

Stations 14 and 15

In the two uppermost stations, 14 and 15, we made only a single electrofishing run. It was on October 15, the day the second run on stations 1-13 ended. Body length and weight data were taken as in stations 1-13. The single-run sample was expanded to a population estimate according to the recapture ratio obtained in stations 1-13, combined. Biomass was calculated as described for stations 1-13.

Habitat Measurements

Throughout the study area, we took measurements to determine the length, mean width and area of each station. We measured width of the water surface at 10-m intervals, except in (short) station 13, where measurements were at 5-m intervals.

Detailed inventory of instream hiding cover and pools was made November 26 in the stations above Sioux Crossing road, except for the combined 31 m of stations 13-14, where ice prevented measurements. Classed as solid overhead cover--capable of providing vertical concealment to trout of "fishable" size--were undercut banks, rocks, logs, stumps and brush, if submerged or within 50 cm above water surface and at least 9 cm (3.5 inches) wide, with at least 15 cm (6 inches) of water beneath them (criteria of Wesche 1973). Areas were classed as pools if water depth was 40 cm (16 inches) or greater (criteria of Binns 1982). The "squared-off" length and width of each cover item and pool were recorded.

Streamflow discharge was measured on November 26 at the upper end of the first riffle below the Sioux Crossing road culvert. We used a pigmy-type Gurley meter. The meter did not quite pass the standard "spin test" and appeared not to be running quite freely in the water. Therefore, the measurement must be regarded as a low estimate (see first paragraph, p. 4).

Sampling of Benthic Invertebrates

On October 15, samples of benthic (streambed) invertebrate animals were taken at two riffle sites: (1) at the lower end of station 12, where a high bank rises steeply at the east side of the creek just upstream from the cattle ford in the park-like above Sioux Crossing road and (2) in the upper part of station 8, which is downstream of the first debris dam below the road. At each site, six samples were taken with a one-square-foot Surber sampler, the first three samples being combined in one bottle of preservative, and the second three combined in another. The preserved organisms were later sorted by taxon and counted in the laboratory. Indices of fish-food abundance and diversity were calculated according to methods used in the Wyoming Habitat Quality Index (HQI) of Binns (1982).

RESULTS AND DISCUSSION

General Observations

The study area has three broadly recognizable habitat types: (1) deep beaver ponds, (2) well-formed meander channels with deep pools and undercut banks at the bends, and (3) swift, shallow water. The first two types are scarce and held high concentrations of fishable-sized cutthroat and brown trout (8-12 inches, rarely larger). Most of the stream is shallow, swift water and contained few trout of fishable size.

Cutthroat and brown trout, both numerous, were the only kinds of fish encountered (Table 3). Commonly, few other kinds of fish coexist with trout in small streams, but complete absence of minnows or sculpins may be unusual.

The vast majority of the trout were of small size--ca 30-130 mm or 1-5 inches (Table 3). About 86% of the cutthroat and 70% of the brown trout were smaller than 130 mm or 5 inches[1]. For both species, most of these small fish were young of the year (age 0), indicating good reproduction in this part of the stream. A high proportion of young fish is normal in healthy, wild trout populations. As is the case for most kinds of fish, death rates are high, and a large supply of young is needed to provide even relatively few fish of fishable size. Also, the ample reserve of young can furnish more large trout than presently exist, whenever survival rates are improved by better conditions, such as a series of years when low flow is less severe than normal, or when there is increased availablity of proper hiding and feeding sites.

The study section contained 49 kg (108 lb) of cutthroat trout and 19 kg (42 lb) of brown trout (Table 4). Some of latter were spawning-season migrants from the Yellowstone River, as evidenced by finclip markings from MDFWP studies in that river. Both species appeared to have slow growth in body size, and there were very few fish of either species that exceeded 12 inches in length--none over 14 inches. The brown trout averaged larger body size than the cutthroat.

The 60-kg/km (213-lb/mi) mean lineal standing crop of trout in the study section was about normal for North American trout streams of its size (Table 5). However, aside from beaver-pond areas, which held far greater standing crop than normal for trout streams (stations 1, 2 and 6, averaging 255 kg/km), the creek averaged only 32 kg/km.

Within the non-beaverpond habitat, the small amount of creek having well-developed meandering channel compared favorably in terms of standing crop with other U.S. trout streams of similar size (Table 5). Only two stations had substantial amounts of such habitat: station 15 with 125 kg/km and station 5 with 116 kg/km.

The remaining majority of the creek was primarily shallow, swift habitat and had a mean standing crop of only 22 kg/km (range of 8-36 kg/km in 8 stations). This was similar to values for small streams in Michigan's Upper Peninsula (Table 5), also an area of harsh winters and short growing season.

The East Fork's present average <u>areal</u> standing crop of trout is somewhat lower than the cattle densities supported on Western U.S. range, but with proper management might be much higher. The average acre of Western U.S. mountain range land has about 280 lb (321 kg/ha) of cattle (0.28 AUM) on it each year (Clayton Marlowe, Montana State University Dept. of Range Science, personal communication 1984--quoting from "The Nation's Rangeland Resources," published in 1972). While the study area had a mean of 149 lb of trout per acre (171 kg/ha - Table 4), the beaver-pond stations held 386 lb/a (443 kg/ha), and the meander habitat had 307 lb/a (353 kg/ha). With creation of

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1. The estimates of the numbers of trout are based on capture efficiencies of 25-40% for fish under 8 cm (3 inches) and of 60-90% for fish of 19-35 cm (7.5-13.5 inches). The resulting errors of estimate at the 95% confidence level--which depend on number of fish in the size group, as well as on capture efficiency--range from around 2-10% below the point estimate to 20-50% above it. For the most important trout group from the fishing standpoint, the cutthroat trout larger than 7.5 inches (19 cm), the error range is - 6% to +24% of the point estimate. The estimates presented in this report can be sonsidered conservative.

pool and meander habitat with more hiding cover, the creek's average standing crop of trout should rise to well above the mean for standing crop of beef on the surrounding land, if the AUMs there are near or below the mean for Western mountain range land.

The above comparison of trout and beef standing crops is primarily for curiosity's sake and ought not be considered tremendously meaningful without further analysis. A properly protected stream should ordinarily have higher animal production than the surrounding land. It receives the nutrients washed from the drainage basin (with beaver dams being important in accumulating these), so its production must be recognized as deriving from the entire drainage basin. Also, moisture is certainly less limiting, although fluctuation of flow, with frequent unfavorably low flow and occasional complete dewatering of channels commonly hampers fish production in the West. Another factor complicating the comparison of production by trout in streams and cattle on land is that the trout have a longer, hence less efficient, food chain. Cattle make direct use of plants, the so-called primary producers. In contrast, the stream's plant material--usually not primarily aquatic plants but fallen leaves and other detritus from the land--must be incorporated in aquatic invertebrate animals, where much energy is lost, before trout can eat it. Therefore, while a stream, having more nutrient and less drouth, will almost certainly produce far more animal matter than surrounding land, most of the animal matter must usually be in the form of insects rather than fish.

Benefits of Beaver Dams and Other Obstructions

Beaver are a major beneficial influence on trout habitat in the study area. Both active, deep-water beaver ponds (stations 1, 2 and 6) and old, sediment-filled, abandoned beaver ponds (station 5 being the best example) are important to trout. In the fine-grained sediment deposits of abandoned ponds, the stream has carved well-developed meanders with deep pools at the bends. In these old "beaver flats," willow brush and meadow plants enhance bank stability and the formation of sheltering undercuts for trout. These observations of benefits of beaver activity on trout in the East Fork are consistent with the findings of Munther (1981) in Western Montana mountain creeks.

The low, dense shrubby and meadow vegetation presently thrives in the beaver flats apparently because the cutting and flooding by beaver has removed most of the large trees whose canopy reduces undergrowth along more forested parts of the creek. Cattle have done some damage to this important meadow and willow vegetation, but obviously not as severely as is common along many streams in grazed areas of Montana.

Of similar benefit are other obstructions, such as various log jams and rock masses. This was particularly true of station 15, where the water had slowed and sediments had deposited behind a barrier of large rock fragments that had apparently been thrown across the creek in stations 13 and 14 by blasting to build the irrigation ditch that parallels the stream in this area. Here also, the current has carved meanders with deep pools at the bends. Other obstacles, primarily log jams and debis dams also slow the current at verious places. Some of these have fairly well-formed pools in the sediments above them, and most have plunge pools just below them.

In terms of areal density (as opposed to lineal density), trout abundance in the meander habitat was virtually as great as in the deep beaver ponds (Table 4). Meander stations 5 and 15 held some 1600 and 1400 over-20-cm (over-8-inch) trout per hectare, while beaver-pond stations 1, 2 and 6 contained 1585, 2239 and 1300. In terms of total standing crop, stations 5 and 15 held 380 and 340 kg/ha, while stations 1, 2 and 6 had 366, 465 and 348 kg/ha. If density per "wetted volume" of stream were calculated, the meander areas would probably be superior. In contrast to the meander and beaver-pond stations, the rest of the stream, with few pools and relatively little cover averaged only 179 over-20-cm trout/ha and 71 kg/ha.

In terms of lineal trout density, there was greater difference between meander and deep beaver dam areas (Table 6; Figure 1)--owing to disparity of channel widths. The beaver ponds averaged 122 over-20-cm trout/km and 27 kg/km, while the meander stations averaged 51 over-20-cm trout/km and 12 kg/km. The rest of the stream averaged only 6 over-20-cm trout/km and 2 kg/km. In terms of over-25-cm (over-10-inch) trout, the beaver ponds may have even greater advantage (Table 6).

Key Importance of Lateral Cover

During the electrofishing in all of the stream but the beaver ponds, most fishable-sized trout were caught from beneath "lateral cover," consisting of undercut banks and associated stream-edge logs, brush debris and dense live vegetation with concentrated current veering beneath or very close along it. It appears that the meander habitat has such great abundance of trout largely because substantial amounts of lateral cover occur in conjunction with pools there.

Not only in this creek, but in the other two rather swift streams I electrofished in 1983--an even smaller mountain brook near Dillon and a large river in Vermont--, pools and other areas with current-swept lateral cover harbored distinctly greater abundance of trout than did open pools with current surging through the center. Similarly, a recent study in a small Western Montana stream found little or no response of a trout population to creation of open pools with low barriers (Lere 1982).

In the creek near Dillon, lateral cover occurred along rock wing deflectors we had installed, and also in weed beds that formed in relatively slack water behind low log sills we had constructed. In the East Fork study area and in the other two streams, lateral cover also harbored many more trout than did isolated midstream logs and rocks. Lateral cover is undoubtedly the most important form of trout cover in the study area--other than fresh beaver ponds--and would be a major feature to enhance in improving the creek.

This finding of the superiority of lateral cover over open pools is of major inportance. It is consistent with but more pronounced than similar observations in less swift streams I have studied, primarily in the Middle West. This has altered my thinking about design of habitat management in mountain streams. Previously, I had thought there should be almost exclusive emphasis on creation of pools in "plunges" below low log sills. Now it is apparent that the plunge pools should be lined with lateral cover, and that the impoundment pools above the sills can also be important, if containing lateral cover. Moreover, wing deflectors can also be effective in mountain creeks--if built to withstand high water.

Detailed Measurements of Instream Cover

Density of instream cover in most of the study section is poor compared with the norm for western trout streams. This seemed fairly obvious in most of the study section. It was definitely the case in the four stations (all above Sioux Crossing) where it was measured, including station 15, one of the better stations in terms of trout population and (apparent) relative habitat quality. On the 0-to-4 scale of Binns' (1979, 1982) trout stream Habitat Quality Index (HQI), cover rating is zero when cover amounts to less than 10% of stream surface area, and the top rating of 4 is for cover that is 55% or more of stream area. Only in station 15, with 9% cover area, was there a value even approaching 10%; The other three stations had values of only 4 or 5% (Table 7). Lack of instream hiding- and security-cover is undoubtedly a principal limitation on trout abundance in this part of the East Fork.

Cover density varied greatly between the four stations and was roughly correlated with abundance of trout. On a per-100-m basis, station 15 had by far the most solid overhead cover and the most pool area (Table 7), and that station also held the greatest density of trout among the four stations (Tables 4 & 6; Figure 1).

Table 7. Detailed measurements of instream cover for trout in stations above Sioux Crossing road, East Fork of Duck Creek, November 26, 1983. Total length of the four stations was 414 m, and total area was 1343 sq m (Table 1).

	Solid overhead cover (sq m)									
	Stream-edge undercut bank, brush and debris		Midstream Log & stump	Midstream Rock	Total		Pool		Total of all cover		
Station	Tot	/100m	Tot	Tot	Tot	/100m	Tot	/100m	Tot	/100m	% of area
UPSTREAM											
15	12.62	(19.0)	0.48	0.00	13.10	(19.7)	9.04	(13.6)	22.14	(33.3)	9.1
13-14	*	*	*	*	*	*	*	*	*	*	*
12	7.45	(6.7)	1.01	1.18	9.64	(8.6)	3.38	(3.0)	13.02	(11.7)	4.1
11	14.27	(11.2)	2.37	0.00	16.64	(13.1)	7.73	(6.1)	24.37	(19.1)	5.1
10	6.69	(6.1)	0.04	0.02	6.75	(6.2)	6.08	(5.6)	12.83	(11.7)	4.1
Total	41.03		3.90	1.20	46.13		26.23		72.76		
Mean		(9.9)				(11.1)		(6.3)		(17.6)	5.4

* Unmeasurable due to ice cover.

Effects of Cattle Grazing

Although most of the immediate stream bank in the study area has been only lightly grazed, and some parts are so protected by thickets and steep banks that they have hardly been grazed at all, some banks have been severely damaged. The worst grazing damage was immediately downstream from the Sioux Crossing road, for a distance of some 60-80 m. Apparently, cattle concentrate there at times, for one reason or another. One other area of special cencern is station 5, where trampling by cattle is breaking down the excellent grassy undercut bank along one of the best meander-bend pools in the study area.

Cattle grazing, if intense, can ruin conditions for beaver ans thereby cause disintegration of trout habitat in mountain streams (Munther 1981). This occurs when cattle concentrate along streams and browse the willow year after year, damaging ("hedging") the lower parts of large willow and killing off willow shoot reproduction, so that there is inadequate repalcement of mature willows that the beaver harvest. Eventually, the willow stands can no longer sustain beaver, which then disappear. Their dams deteriorate and wash out and, especially under continued pounding by the cattle, the stream erodes a "downcut" channel lacking pools and cover.

Abundance of Young Trout

Lineal density of young (age-0) trout was substantial throughout most of the study area. These fish had shallow riffles as their primary habitat. In several of the shallow areas, notably the partially dewatered stations 3 and 4, age-0 density was essentially the same as in the meandered and beaver-pond areas--except that station 6, a beaver pond with an excellent riffle at its upper end, had higher density of young than did any other station (Table 6; Figure 1).

Trout Species Composition

Cutthroat trout were more abundant than brown trout at most body sizes (Table 3) in almost all stations (Table 6). In terms of lineal density of larger fish and of biomass, cutthroat predominance was greatest in beaver ponds, slightly lower in meander stations, and much lower in shallow, swift habitat (Table 6). Species composition probably did not differ greatly between the pond and meander habitat, based on areal densities, as the ponds are so much wider. In beaver ponds and in shallow creek (but not in meandered creek), the cutthroat predominance over brown trout was greater at age 0 than at larger sizes (Table 6).

These results are consistent with the theory that various strains of cutthroat trout (of which this must be one), having evolved in Rocky Mountain creeks where beaver are prevalent, are to significant degree a beaver-pond-adapted fish. Perhaps the brown trout strain present is not particularly adapted to beaver activity and is more of a "stream-dweller," putting the cutthroats at some sort of competitive advantage in quieter water. Such observations on habitat-related differences in species composition must be considered tenuous, as the distribution of brown trout, especially the larger ones, may have been affected at this season by movement toward spawning gravels located in the creek riffles.

Movement of Trout from the Yellowstone River

A few trout of both species bore markings (tail-fin notches) recently made during trout population studies by the Montana Department of Fish, Wildlife and Parks in the Yellowstone River. This evidence of movement from the Yellowstone River was not surprising in the case of large, mature brown trout, which spawn in fall and may seek spawning habitat in side creeks. However, there were also small, immature brown trout, as well as both small and large cutthroat trout, which had these marks. The immature brown trout could not have migrated to spawn. The cutthroat trout are springtime spawners. It is worth noting that all the marked trout we caught had to have traversed one or more large beaver dams. Other studies have found that upstream migration of salmonids is not significantly inhibited by beaver dams (Rasmussen 1941, Rutherford 1964), and our results indicate that their dams may not be much of a problem for migrants even in fall when there is no high water to ease passage.

Body Growth of Trout

On the basis of length frequency distributions, the cutthroat trout appear to be very slow-growing and significantly smaller than brown trout of the same age group (Table 8; Figures 2, 3 and 4). The brown trout have a several-month head start in life and probably also grow faster than the cutthroats. The age-0 brown trout, having been spawned in the previous fall and having hatched in spring, were much larger at the time of electrofishing than the age-0 cutthroat trout, which had been spawned the spring and hatched in summer. The size disparity apparently increased due to the differential rates of growth, so that in October, brown trout yearlings were as large as and larger than 2-year-old cutthroat trout.

Table 8. Length at age East Fork Duck Creek trout, October 1984, tentatively determined from Figures 2, 3 and 4.

	Cutthroat trout				Brown trout	
	Beaver ponds**		Stations 3-9		in stations 1-15	
Age	mm	(inches)	mm	(inches)	mm	(inches)
0	41-62	(1.6-2.4)	33-62	(1.3-2.4)	55-92	(2.2-3.6)
I	79-122	(3.1-4.8)	73-116	(2.9-4.6)	122-180	(4.8-7.1)
II	133-168	(5.2-6.6)	120-151	(4.7-5.9)	190- ?	(7.5- ?)
III	174-214*	(6.8-8.4)	161- ?	(6.3- ?)		

* Approximate. ** Stations 1 and 2.

It is quite likely that the cutthroat trout do not reach a length of 30 cm (12 inches) until they are 5 or 6 years old--exceedingly slow growth, compared to that of midwestern trout. Central Wisconsin brook trout can reach 12 inches as 4-year-olds (though few survive to that age), and in rich spring creeks of southern Wisconsin, brown trout can be 12 inches long as fall 2-year-olds. Growth of cutthroat trout is commonly very slow, even in such large streams as the Yellowstone River (Fred Nelson, MDFWP, personal communication 1984).

Benthic Invertebrates

Streambed sampling revealed an abundance of invertebrate insects, occurring as a diverse community, with the kinds present being typical of cold trout streams (Table 9). There were 3,436 insects collected, sorted, identified and counted in the 12 square feet sampled. These represented 23 taxa when keyed to the levels stipulated for calculation of diversity index by the Wyoming HQI method (Binns 1979, 1982). However, according to more recent knowledge of mayfly taxonomy, 25 taxa were actually present, and since some of the taxa were keyed only to family level, it can be assumed that somewhat more than 25 genera were represented, and, of course still more species than that. Some kinds of benthic insects that occur in the areas sampled were undoubtedly missed, their bodies being so small at this time of year as to pass through the meshes of the collecting net.

Relative to other trout streams, invertebrate abundance was high and diversity very high, according to the Wyoming HQI rating system (Table 9). On scales of 0-4, abundance rating was 3 at the upper site and 2 at the lower site, while diversity was 4 at the upper site and 3 at the lower site. Overall, abundance had a rating of 3, and diversity had a rating of 4.

Density of organisms was greater at the upper than at the lower sampling site. While the station-12 sampling site, about 240 m above the road had 377 organisms/sq ft, the station-8 site, some 60 m below the road, had only 196/sq ft (Table 9). All but 5 taxa were more abundant at the upper site. Four taxa were of equal density at both sites, all being low--only 1 to 9 organisms/sq ft. But a single taxon, the caddis fly, *Arctopsyche grandis*, was more numerous at the lower site.

Strong presence of elmid riffle beetles and some of the other taxa may be a sign of springwater influence, (George Roemhild, Montana State University, personal communication 1984). Relatively strong spring seepage may occur along the high bank at the upper sampling site (it is very evident on the east side of the valley floor upstream from the study area) and may be more of a factor in water quality there than at the lower site.

The poorer density of organisms at the lower site might also be attributable to disturbance of the stream bed by cattle. The upper site is protected by downed logs and a very steep bank--and may have such dense tree canopy that there is not much grass to attract cattle. The creek banks at the lower site are obviously much more heavily trampled. Particularly if cattle had recently grazed there or been driven through that area, their trampling could account for much of the lower invertebrate abundance in station 8. It is also possible that streambed disturbance by the dragging of our electrofishing canoe happened to have been greater at the lower site than at the upper one.

MANAGEMENT RECOMMENDATIONS

1. Creating more "holding" habitat suitable for fishable-sized trout should increase their abundance. It appears that trout reproduction and food supply are more than ample, but that there is a severe lack of security and hiding cover which limits the population of larger-sized fish.

2. Emphasize creation of lateral cover when building instream habitat for trout. This can be done by using low log sills to make downstream plunge pools and upstream impounding pools, then lining the pools in certain ways with log and rock shelters. I have in mind several special designs for the log sill stuctures and the necessary cover installations, based on the best of what we see occurring naturally in this and other mountain creeks, as well as on recent experiences with cover creation in such streams. Judging by results of the recent experiment on instream cover for cutthroat trout in the mountain brook near Dillon, wing deflectors should also be effective in creating lateral cover--if constructed to withstand high water.

3. Protect the existing beaver colonies and promote their expansion. It might be worth exploring the possibility of doing some vegetational management to encourage the spread of beaver along the stream. Perhaps I could bring in some U.S. Forest Service biologists and foresters for a look at the situation. I have mentioned to one of them that the results on the East Fork resemble what they have been finding on National Forests in Western Montana, and some interest has been expressed in seeing the situation on the East Fork.

4. Divert the split flow of stations 3 and 4 back into the main channel. This could be accomplished with a low barrier of rock and earth.

5. Consult a professional hydrologist on the predicted high flows in this part of the creek and on the feasibility of stuctures to withstand the flows.

6. Prevent increase in cattle grazing near the stream--and, if possible, reduce it. Simple barriers of jumbled rock might be installed (as we have done on the Dillon creek) to block streambank grazing in a few critical areas, if streambank fencing or altered pasture fencing are not feasible. From standpoints of initial cost, upkeep, esthetics, high water hazard, and access for fishing, close fencing of stream banks is probably not advisable.

7. Harvest few cutthroat trout, especially under the present status of the habitat and population. Cutthroat trout are exceptionally easy to catch, and heavy cropping is likely to result in loss of the largest ones from the population. Because the cutthroat are so slow-growing, probably taking 5 or 6 years to reach body length of 12 inches, the larger-sized part of the population, if cropped heavily, might not be rapidly replenished--although the immigration that evidently occurs from the Yellowstone River could possibly make up for losses. A further consideration is that elimination of the larger sizes of cutthroat trout may promote more rapid "takeover" of the stream by brown trout than may now be occurring.

8. Harvest as many brown trout as possible. It is quite likely that brown trout are disadvantageous to the cutthroat trout. Of special concern are the large brown trout, which probably prey on small cutthroat trout and may also compete with large cutthroat trout, excluding them from hiding and feeding habitat. Because brown trout are so much harder to catch than cutthroat trout, angling probably will not reduce the brown trout population much, but it may benefit the cutthroat somewhat if every brown trout caught is killed.

9. Control public fishing in the creek. This is a corollary of recommendation 7. Again, the population of fishable-sized cutthroat trout is probably fragile and could not be maintained in the face of intense harvest. These fish, now concentrated in the creek's few pockets of suitable habitat, could be easily wiped out by a few skillful anglers who discover them (as commonly happens in small brook trout streams back east), and the population would be long in recovering. For this reason, obvious stream improvement within sight of the road would be inadvisable. At present, the creek must look uninterestingly small and unproductive to most passers by. It would be well to maintain this ininviting appearance. An alternative might be to restrict public fishing to flies-only, catch-and-release angling, but it could be impractical to administer this effectively. Most anglers would consider such a small, brushy creek as baitfishing rather than flyfishing water, and for other reasons, getting compliance with any special regulation would probably be a headache.

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Department of Fish, Wildlife and Park. Daniel Gustafson did the benthic invertebrate sampling and analysis, consulting George Roemhild on some aspects. Assisting with measurements of stream dimensions and cover were Almut White, Sven White, Brandon Kaya and Daniel Gustafson.

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Table 1. Station dimensions and marker locations, East Fork of Duck Creek.

Station	Length (m)	Width (m) Mean	SD*	n**	Area (ha)	Location of upstream marker***
UPSTREAM						
15	66.4	3.68	0.93	7	.0244	Overhanging conifer bough within sight of MacMillan home.
14#	14.8	5.37	2.36	3	.0079	Upper edge of "fallen rock" area.
13#	16.5	1.95	1.14	4	.0032	Flagged leaning conifer tree on east bank.
12	111.5	2.80	0.52	12	.0312	Lower edge of "fallen rock" area.
11	127.3	3.74	1.79	12	.0476	Large flagged tree trunks close above ford in cattle path at upper end of parklike area at Sioux Crossing.
10	109.1	2.85	0.73	11	.0311	First large log-and-debris dam above road.
-------	10.3	(2.3 est.)				-- Sioux Crossing road culvert -------
9	53.1	4.02	1.49	6	.0213	Lower edge of road culvert.
8	73.6	2.54	0.53	9	.0187	First large log-and-debris dam below road.
7	173.7	3.05	0.89	17	.0530	Flagged deciduous tree on high, steep dirt south bank.
6	34.4	4.23	1.26	5	.0145	Large log jam above densely thicketed area.
5	40.0	3.06	0.91	4	.0122	Small active beaver dam at upper end of small meadow area formed by deposition in large abandoned beaver dam.
-------	16.9	(2.5 est.)				-- Area clogged with log jams just below old beaver dam -------
4	76.9	2.14	0.65	8	.0165	Lower end of log-jam area.
3	148.2	2.95	1.17	15	.0437	Very high log jam.
2	53.4	7.61	3.44	5	.0406	Beaver dam in narrow channel just above large beaver pond.
1	44.5	7.23	1.39	6	.0322	Very high beaver dam above lower-most large beaver pond.
Total	1170.65	3.46		124	.4054	
	(1143.45)	(3.49)		(124)	(.3988)	(The area electrofished.)

* Standard deviation.
** Number of width measurements.
*** Upper boundaries of stations marked by tape bearing station number and attached to tree or bush.
\# Stations 13 and 14 are the same habitat type (Table 2). Their data were combined in most analyses.

Table 2. General habitat characteristics and problems of stations in the East Fork of Duck Creek.

Station	Length (m)	Habitat characteristics	Habitat problems
15	66.4	Head end riffles; lower part has developed deep meander pools in sediments behind the damming caused by blasted rock in station 13-14.	Shallowness and lack of cover in riffles.
13-14	31.5	A jumble of large rock from blasting of cliff to form irrigation ditch.	Poorly defined channel. Lack of pools and cover.
12	111.5	Riffly and free-flowing. Few pools.	Lack of depth and cover. Some streambank damage by cattle.
11	127.3	Shallow riffles with much obstruction by fallen trees (mainly beaver-felled) and debris dams that have trapped silt.	Lack of depth and cover. Poorly defined channel in places. Some streambank damage by cattle.
10	109.1	Shallow riffles and one large pool.	Lack of depth and cover.
	10.3	-- Sioux Crossing road culvert	
9	53.1	Deep pool below culvert. Riffles and another pool behind debris dam.	Lack of cover. Severe streambank damage by cattle.
8	73.6	Shallow riffles.	Lack of depth and cover. Some streambank damage by cattle.
7	173.7	Shallow riffles with few minor pools.	Lack of depth and cover.
6	34.4	Some riffle. Slow meander-bend pools, deepened by small active beaver dam. Dense brush protects stream banks from cattle.	None!
5	40.0	Slow meander-bend pool carved by stream in sediment deposited behind large abandoned beaver dam.	Stream banks deteriorating due to grazing and trampling of cattle. Old beaver dam eroding, which diverts much of flow away from channel.
	16.9	-- Log jams	
4	76.4	Mainly shallow riffle.	Contains only about half the flow of the stream, due to splitting of the channel at old beaver dam, described above.
3	148.2	Mainly shallow riffle. Flow from new channel rejoins near downstream end of station.	Same as station 4.
2	53.4	Large, active beaver pond.	None.
1	44.5	Large, active beaver pond.	None.

Table 3. Length frequency distributions of trout in the Sioux Crossing study area of the East Fork of Duck Creek, October 1983.

Length group		Cutthroat trout			Brown trout			Total		
mm	inches	Number	%	Cum %	Number	%	Cum %	Number	%	Cum %
		A G E - 0 F I S H						AGE-0 AND OTHER FISH OF 33-129mm (1.3-5.1 in)		
33-62	1.3-2.4	1641	65.1	65.1	479 (55-92mm or 2.2-3.6 in)	66.8	66.8	2678	82.7	82.7
		O L D E R F I S H						FISH LARGER THAN 129 mm (5.1 in)		
70-89	2.8-3.5	112	4.4	69.5						
90-109	3.5-4.3	262	10.4	79.9						
110-129	4.3-5.1	153	6.1	86.0	31 (100-129 mm)	4.3	71.1			
130-149	5.1-5.9	29	1.2	87.2	80	11.1	82.2	109	3.3	86.0
150-169	5.9-6.6	32	1.3	88.5	43	6.0	88.2	75	2.3	88.3
170-189	6.7-7.4	50	2.0	90.5	8	1.1	89.3	58	1.8	90.1
190-209	7.5-8.2	44	1.7	92.2	8	1.1	90.4	52	1.6	91.7
210-229	8.3-9.0	56	2.2	94.4	26	3.6	94.0	82	2.5	94.2
230-249	9.1-9.8	50	2.0	96.4	13	1.8	95.8	63	1.9	96.1
250-269	9.8-10.6	43	1.7	98.1	9	1.2	97.0	52	1.6	97.7
270-289	10.6-11.4	34	1.3	99.4	13	1.8	98.8	47	1.4	99.1
290-309	11.4-12.2	14	0.5	99.9	5	0.7	99.5	19	0.6	99.7
310-329	12.2-13.0	1	0.04	99.9	1	0.1	99.6	2	0.06	99.8
330-349	13.0-13.7				1	0.1	99.7	1	0.03	99.8
Totals		2521	99.9		717	99.7		3238	99.8	

Table 4. Absolute abundance and density of trout (cut = cutthroat; brn = brown) in Sioux Crossing study section, East Fork of Duck Creek, October 1983. Some fish between the size of age-0 fish and 150mm do not show up in this array, but their weights are included in biomass.

				Number of Fish																			
				Age 0*					150 mm (6 in) and larger					200 mm (8 in) and larger					Biomass (kg)				
Sta-tion	Length (m)	Mean width (m)	Area (ha)	Cut	Brn	Tot	per 100m	per ha	Cut	Brn	Tot	per 100m	per ha	Cut	Brn	Tot	per 100m	per ha	Cut	Brn	Tot	per 100m	per ha
15	66.4	3.68	0.0244	104	47	151	227	6180	55	13	68	102	2783	28	6	34	51	1391	6.29	1.99	8.28	12.5	338.8
13-14	31.3	3.57	0.0112	23	20	43	137	3848	0	10	10	32	895	0	0	0	0	0	0.23	0.18	0.41	1.3	36.5
12	111.5	2.80	0.0312	40	58	98	88	3139	11	11	11	10	352	5	6	11	10	352	1.44	1.41	2.85	2.6	91.4
11	127.3	3.74	0.0476	187	72	259	204	5440	11	8	19	15	399	4	1	5	4	105	1.85	0.92	2.77	2.2	58.2
10	109.1	2.85	0.0311	83	11	94	86	3023	4	8	12	11	386	2	3	5	5	161	0.77	0.90	1.67	1.5	53.8
9	53.1	4.02	0.0213	88	10	98	185	4591	12	3	15	28	703	6	0	6	11	281	1.62	0.30	1.92	3.6	90.1
8	73.6	2.54	0.0187	101	18	119	162	6366	1	1	2	3	107	1	0	1	1	53	0.38	0.24	0.62	.8	33.3
7	173.7	3.05	0.0530	112	17	129	74	2435	14	18	32	18	604	8	8	16	9	302	2.49	2.21	4.70	2.7	88.6
6	34.4	4.23	0.0146	156	30	186	541	12782	25	7	32	93	2199	15	4	19	55	1306	3.95	1.12	5.07	14.7	348.2
5	40.0	3.06	0.0122	66	39	105	262	8578	15	9	24	60	1961	13	7	20	50	1634	2.97	1.68	4.65	11.6	379.7
4	76.9	2.13	0.0164	94	100	194	252	11844	3	7	10	13	611	0	1	1	1	61	0.75	0.83	1.58	2.0	96.3
3	148.2	2.95	0.0437	348	38	386	260	8829	5	8	13	9	297	3	3	6	4	91	1.66	1.32	2.98	2.0	68.1
2	53.4	7.61	0.0406	132	11	143	268	3519	105	13	118	221	2904	78	13	91	170	2239	16.24	2.66	18.90	35.4	465.1
1	44.5	7.23	0.0322	108	7	115	258	3574	63	20	83	187	2580	35	16	51	115	1585	8.55	3.24	11.79	26.5	366.4
Total	1143.4		0.3993	1642	478	2120			324	125	449			196	68	264			49.19	19.00	68.19		
Mean		3.48					185	5323				39	1127				23	663				6.0	171.2
Stations without major active beaver impoundment (all but 1,2,6)																							
Total	1011.1		0.3109	1246	430	1676			131	85	216			68	35	103			20.44	11.99	32.43		
Mean		3.07					166	5391				21	695				10	331				3.2	104.3
Stations without any major impoundment (all but 1,2,5,6,15)																							
Total	904.7		0.2742	1076	344	1420			61	63	124			27	22	49			11.18	8.32	19.50		
Mean		3.03					157	5178				14	452				5	179				2.2	71.1

* Age-0 cutthroat trout are 33-62 mm. Age-0 brown trout are 55-92 mm.

Table 5. Lineal standing crop of trout in U.S. streams.

Stream	No. of streams	No. of Sec-tions	Stream width (m)	Standing crop (kg/km) Mean	Range	Source
E. Fork of Duck Cr. (mean)	1	14	3.49	60	8-354	1
Beaver ponds (sta 1, 2, 6)		3	4-7.6	271	147-354	1
Meander-pool areas (sta 5, 15)		2	3-3.7	122	116-125	1
Remainder of study section		9	2-4	22	8-36	1
Southwest Montana						
Small streams	17	31	?	69	9-222	4
Wyoming						
All streams studied	37	44	1-45	54	0-393	3
Central Michigan & Wisc.						
Small streams	11	15	2.6-10.6	60	13-143	2
Central Michigan						
Medium-large streams	6	6	13-34	150	33-366	2
Upper Michigan						
Small streams	6	7	4-11	22	7-37	2

Sources: 1. This study; 2. White 1983; 3. Binns 1979; 4. White et al. 1983.

Table 6. Lineal density and species composition of trout, compared by habitat type. East Fork of Duck Creek, October 1983.

Sta-tion	Len-gth (m)	Mean width (m)	Number of trout per 100 m: Age 0 CT*	BN**	Tot	(%CT)	Over 20 cm CT	BN	Tot	(%CT)	Over 25 cm CT	BN	Tot	(%CT)	Standing crop (kg/100 m) CT	BN	Tot	(%CT)
Stations predominated by beaver pond																		
6	34.4	4.23	453	87	541	(84)	44	12	56	(79)	23	3	26	(88)	11.48	3.26	14.74	(78)
2	53.4	7.61	247	21	268	(92)	146	24	170	(86)	80	19	99	(81)	30.41	4.98	35.39	(86)
1	44.5	7.23	243	16	258	(94)	79	36	115	(69)	32	11	43	(74)	19.21	7.28	26.49	(73)
Total	132.3																	
Mean		6.61	299	36	336	(89)	97	25	122	(80)	45	11	56	(80)	21.72	5.31	27.03	(80)
Stations predominated by deep meanders																		
15	66.4	3.68	157	71	227	(69)	42	9	51	(82)	18	4.5	23	(78)	9.47	3.00	12.47	(76)
5	40.0	3.06	165	98	263	(63)	33	18	51	(65)	10	5.0	15	(67)	7.43	4.20	11.63	(64)
Total	106.4																	
Mean		3.45	160	81	241	(66)	39	12	51	(76)	14	5	19	(74)	8.70	3.45	12.15	(72)
Stations predominated by shallow, swift creek habitat																		
13-14	31.3	3.57	73	64	137	(53)	0	0	0	--	0.0	0.0	0.0	--	0.73	0.58	1.31	(56)
12	111.5	2.80	36	52	88	(41)	4	5	10	(45)	1.8	1.8	3.6	(50)	1.29	1.26	2.56	(51)
11	127.3	3.74	147	57	203	(72)	3	1	4	(80)	0.0	0.8	0.8	(0)	1.45	0.72	2.18	(67)
10	109.1	2.85	76	10	86	(88)	2	3	5	(40)	0.9	1.8	2.7	(33)	0.71	0.82	1.53	(46)
9	53.1	4.02	166	19	185	(90)	11	2	13	(86)	5.6	0.0	5.6	(100)	3.05	0.56	3.62	(84)
8	73.6	2.54	137	24	162	(85)	1	0	1	1(00)	1.4	0.0	1.4	(100)	0.52	0.33	0.84	(61)
7	173.7	3.05	64	10	74	(87)	5	5	10	(50)	1.7	1.2	2.9	(59)	1.43	1.27	2.71	(53)
4	76.9	2.13	122	130	252	(43)	0	1	1	(0)	0.0	0.0	0.0	--	0.98	1.08	2.05	(47)
3	148.2	2.95	235	26	260	(90)	2	2	5	(50)	0.7	1.3	2.0	(35)	1.12	0.89	2.01	(56)
Total	904.7																	
Mean		3.03	119	38	157	(76)	3.2	2.5	5.7	(56)	1.3	0.8	2.1	(62)	1.24	0.92	2.16	(57)
Grand Total	1143.4																	
Mean		3.48	144	42	185	(77)	17	6	23	(74)	7.0	2.4	9.4	(74)	4.30	1.66	5.96	(72)

* Cutthroat trout ** Brown trout

Table 9. Benthic invertebrates, Sioux Crossing area, East Fork of Duck Creek, 15 October 1983. Sampling with 1-sq-ft Surber sampler in riffles.

Taxon	Sta 12 (above road) Number in 3-sq-ft group Grp 1	2	Sta 12 Total in 6 sq ft	Sta 8 (below road) Number in 3-sq-ft group Grp 1	2	Sta 8 Total in 6 sq ft	Total
STONEFLIES							
Doroneura theodora	35	19	54	28	17	45	99
Hesperoperla pacifica	1	1	2	1	1	2	4
Zapada	150	29	179	50	41	91	270
Chloroperlidae	25	1	26	1	1	2	28
Perlodidae (young)	3	1	4				4
CADDIS FLIES							
Arctopsyche grandis	96	57	153	119	94	213	366
Dolophiloides	20	19	39	9	3	12	51
Rhyacophila spp.	31	25	56	12	11	23	79
Glossosoma spp.	180	198	378	125	84	209	587
Neothremma alicia	178	60	238	54	60	114	352
Micrasema bactro	72	53	125	48	42	90	215
Limnophilidae (young)	62	39	101	18	11	29	130
Hydropsyche	5	3	8	2	6	8	16
Brachycentrus	1		1	1		1	2
MAYFLIES							
Rhithrogena undulata	117	59	176	56	47	103	279
*Drunella doddsi	48	24	72	8	5	13	85
*Drunella spinifera	11	8	19	3	5	8	27
*Caudatella hystrix	17	9	26	4	8	12	38
*Ephemerella sp.**	16	10	26	3	6	9	35
Baetis tricaudatis	15	9	24	8	5	13	37
Paraleptophlebia sp.	8	3	11	1		1	12
RIFFLE BEETLE							
Elmidae	216	69	285	68	53	121	406
DIPTERAN FLIES							
Pericoma sp.	198	39	237	26	17	43	280
Chironomidae	6	3	9	2	7	9	18
Tipulidae	6	6	12	1	2	3	15
Simulium sp.	1		1				1
Total	1518	744	2262	648	526	1174	3436
Number/sq ft	506	248	377	216	175	196	268
Number of taxa***	23	21	23	21	19	21	23
Diversity score***	7.82	4.97	5.81	3.63	4.42	3.43	4.29
HQI fish food abundance****	4	2(ca 3)	3	2	2	2	3
HQI fish food diversity****	4	4	4	3	4	3	4

* Formerly all *Ephemerella*; Here counted as one genus for diversity score.
** *Ephemerella inermis* or *infrequens*.
*** As used in the Wyoming Habitat Quality Index (Binns 1982).
**** Rating is on a scale of 0-4.

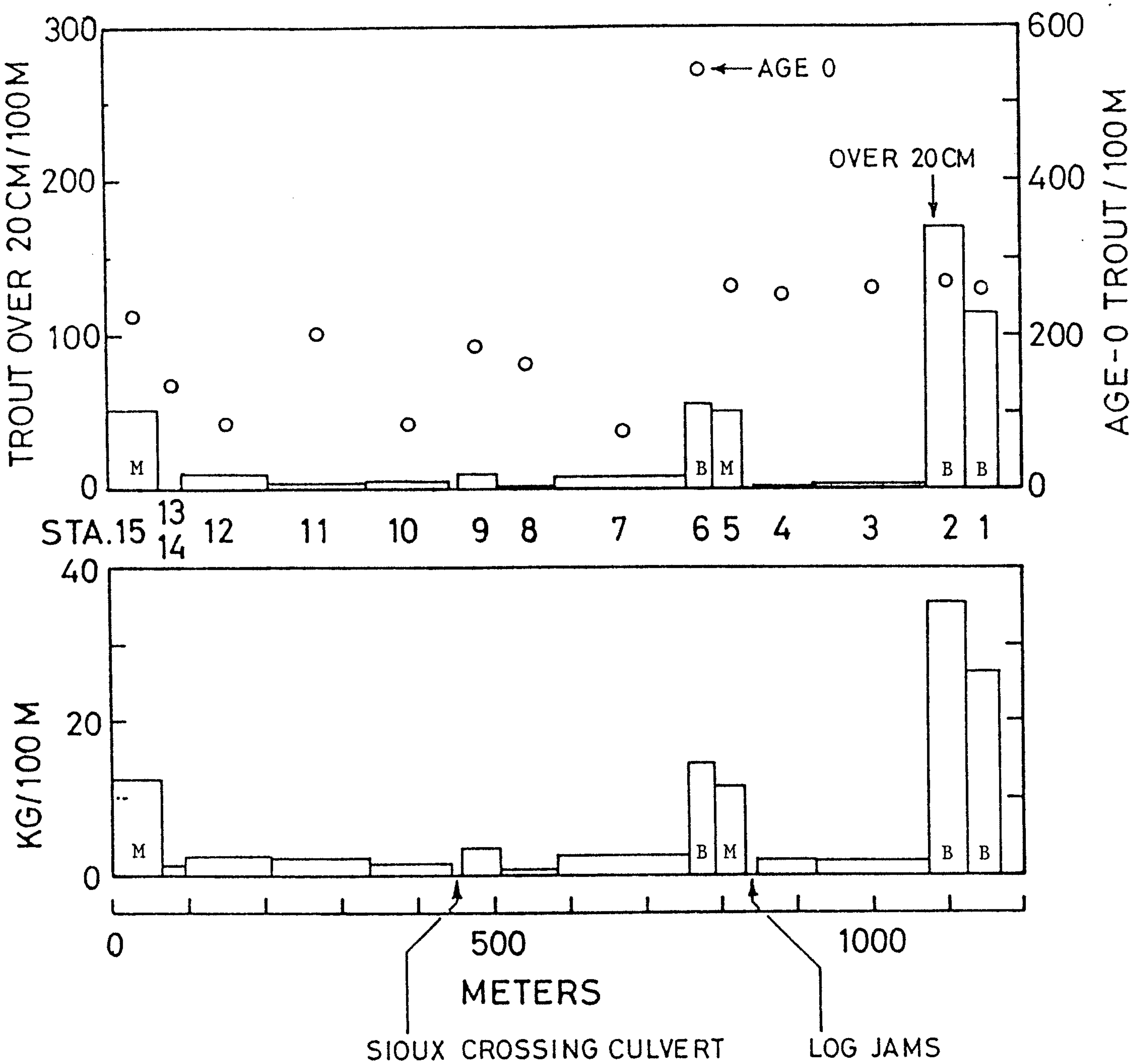

Figure 1. Various expressions of trout abundance (cutthroat and brown trout combined) by stations in the East Fork of Duck Creek, Montana, October 1983. M = meandering channel; B = beaver pond.

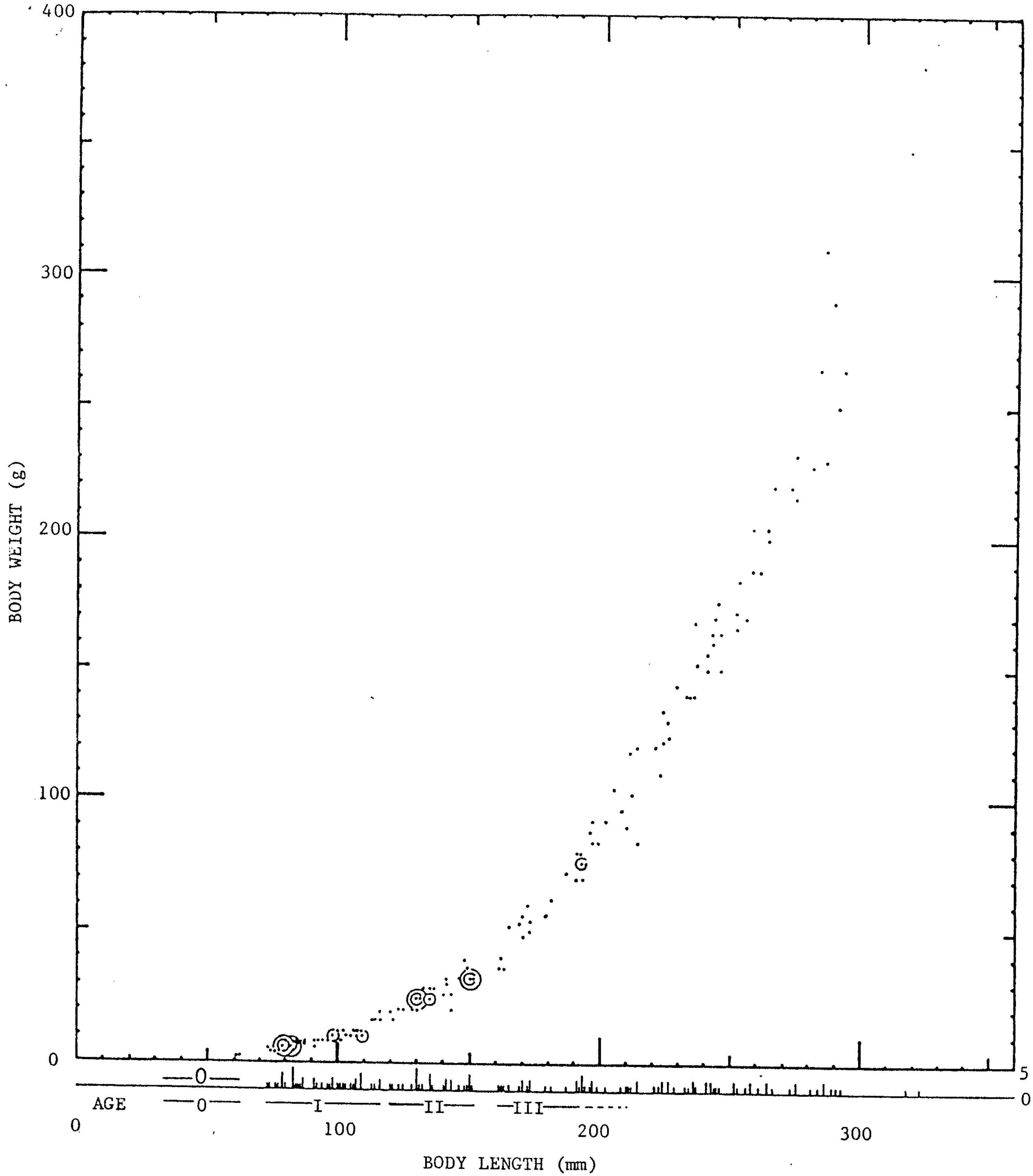

Figure 2. Length-weight relationship and length frequency distribution of cutthroat trout in stations 3-9. Sample size is the number of "new" fish handled in electrofishing. For age 0, there was only partial sampling of lengths, and only the range is shown. Ranges of ages I, II and III based on tentative analysis of clusters in the length-weight plot.

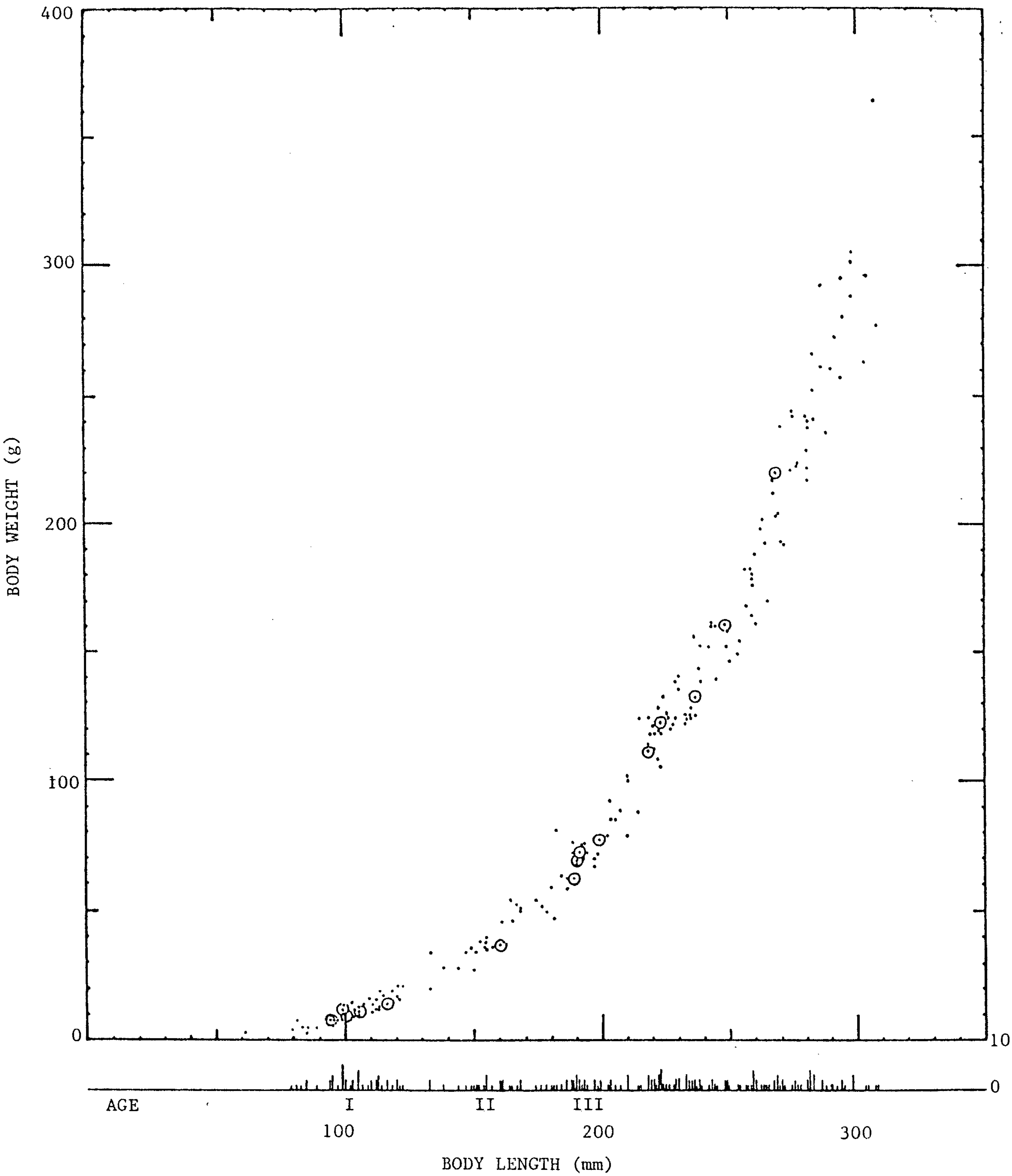

Figure 3. Length-weight relationship and length frequency distribution of cutthroat trout in beaver-pond stations 1 and 2. Sample size is the number of "new" fish handled in electrofishing. Length-range analysis for age groups as in Figure 2.

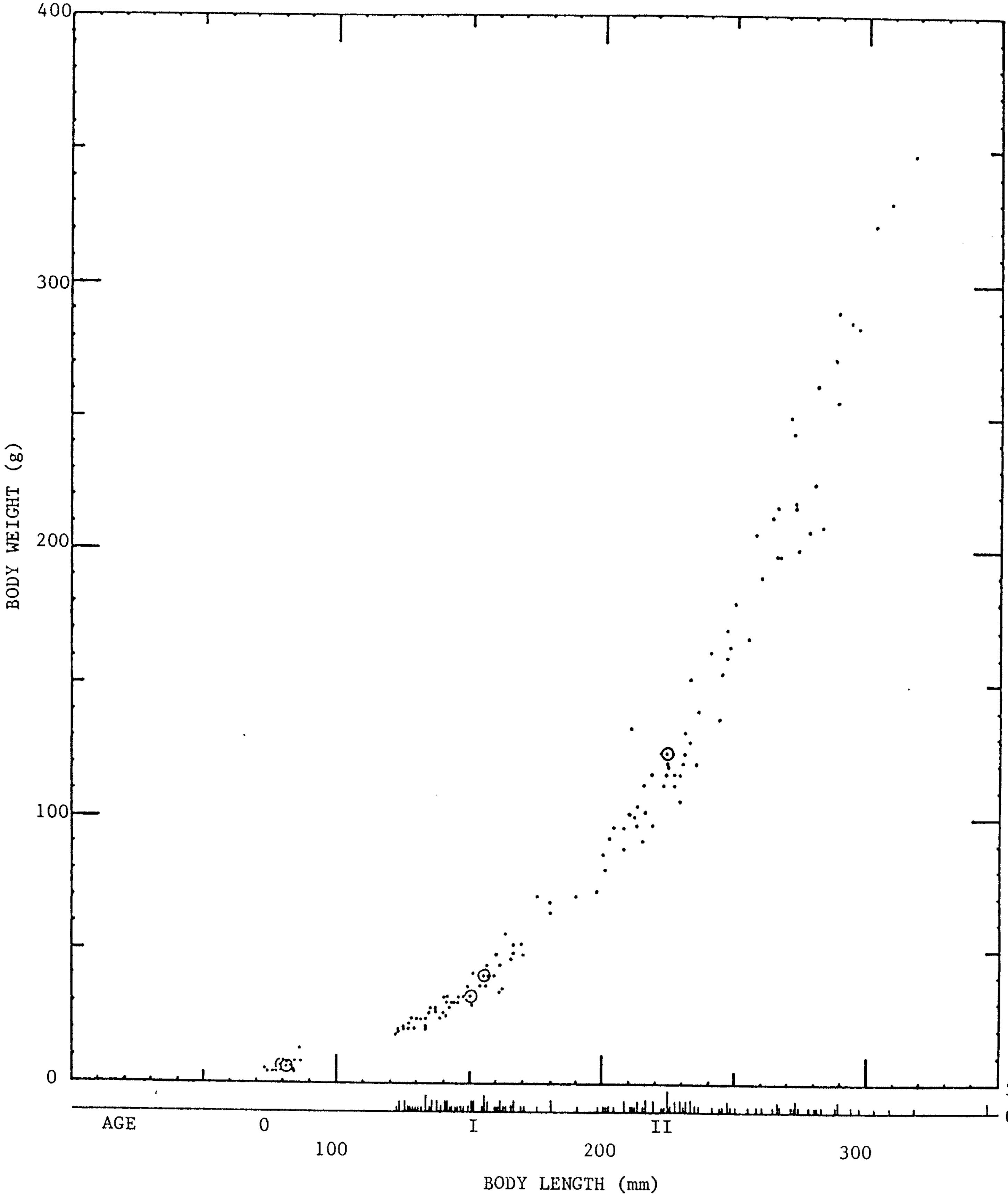

Figure 4. Brown trout length-weight relationship and length frequency distribution in entire study area (stations 1-15). Sample size is the number of "new" fish handled in electrofishing. Length-range analysis for age groups as in Figure 2. Note two data points outside frame.