STREAM MORPHOLOGY AND FISH POPULATIONS IN RELATION TO FLOODPLAIN USE

by

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ABSTRACT

The relationship between flood plain use, stream morphology, and the fish population of two adjacent study sections of Rock Creek, Montana was studied during the summers of 1964 and 1965. One study section received relatively intense livestock use for many years, while the other had only light use. Field measurements gave eroded channel widths of 141 feet and 103 feet and water widths of 74 feet and 66 feet in the grazed and ungrazed sections, respectively. By area, the grazed section consisted of 77.2 percent riffle, 8.5 percent run and 14.3 percent pool, while for the ungrazed, the values were 43.4 percent, 37.6 percent and 19 percent, respectively. There was a greater degree of subdivision and interspersion of water types in the ungrazed section than in the grazed. The extent of cover in relation to water type was determined. The amount of cover per acre of stream was 76.4 percent higher in the ungrazed section than in the grazed. A disproportionately high amount of cover in the grazed section was associated with the deeper water types, since the most marked erosion in the section takes place in areas surrounding riffles. The fish populations of both sections were sampled by means of shocking in the course of a simple mark and recapture census. The total estimated number and pounds of fish per acre were 2,536 and 140.7 in the grazed section and 2,578 and 190.3 in the ungrazed, respectively. Brown trout made up 91 percent of the number of fish captured and 79 percent of the weight. The number and weight per acre of brown trout over 6 inches long were 27 percent and 44 percent greater in the ungrazed section than in the grazed. The growth rate of brown trout was similar for both sections.

INTRODUCTION

The importance of shelter for trout in streams has been recognized for many years (Needham, 1938). Efforts to elucidate the relationship included the habitat improvement studies of Tarzwell (1937, 1938), Shetter, et al. (1946) and Saunders and Smith (1962). Boussu (1954) found that when undercut banks and overhanging brush of a stream were removed, the trout population, especially the larger fish, was adversely affected.

Young beaver ponds with heavy willow cover and deep water generally support larger fish than associated stream areas (Gard, 1961; Knudsen, 1962; Rutherford, 1955; Huey and Wolfrum, 1956). Warner, et al. (1960) stated that the removal of bank vegetation, overhanging banks and other shelter destroyed some of Maine's finest trout streams.

Nelson and Hill (1960) attributed damage to the Rock Creek flood plain by a 1957 flood to the loss of woody vegetation on stream banks and adjacent flood plain through land clearing and livestock grazing.

The objective of the present study was to compare the stream morphology, bank cover and fish populations of two areas--one where the flood plain vegetation was reduced by clearing and grazing and the other where the vegetation was relatively unaltered.

I found where the flood plain vegetation was reduced, the stream channel was wider and had less shelter and fewer trout than the unaltered area.

Description of Area

Rock Creek originates in the Beartooth plateau of Montana and

Wyoming. It flows northeasterly 59 miles to the Clark Fork River of the Yellowstone River drainage.

At its origin, the substrate is Precambrian gneiss and dark schist, with a few dykes of felsite porphry. Near Red Lodge, Montana, the stream flows through limestone and dolomite palisades for a short distance, and thereafter through Pleistocene sands and gravels.

The 20 miles of Rock Creek above Red Lodge have an average gradient of approximately 128 feet per stream mile. The average recorded stream flow near Red Lodge from 1934 to 1964 was 67 cubic feet per second. The middle 23 miles of the stream, between Red Lodge and the mouth of Red Lodge Creek, have an average gradient of 66 feet. During late summer the volume of flow is generally less than in the upper reaches because of diversion for irrigation. The lower 16 miles has a gradient of 35 feet, and the flow is extensively modified by irrigation.

In 1957 and 1958, parts of the lower 40 miles of the creek were subjected to channel clearance and "realignment." This resulted in a wider stream channel that was shallower and shorter and with less cover. Census of a 300-foot sample area in the middle section showed a 75.1 pound-per-acre decrease in trout following alteration (Nelson and Hill, op. cit.).

The present study area, about ten miles below Red Lodge, consisted of two adjacent flood plain sections approximately 3,500 feet long. Only about 1 percent of these sections were subjected to channel alteration.

The vegetation of the upper study section was burned in the 1930's. Continued livestock use since then has prevented the establishment or retarded growth of young shrubs and trees. The landowner stated that roughly 0.5 cattle per acre were confined to the most recent terrace for eleven months of the year.

Cottonwood (Populus trichocarpa), water birch (Betula occidentalis), alder (Alnus spp.) and hawthorne (Crataegus chrysophyta) were present on the flood plain and made up the greater part of the overstory. Very small amounts of willow (Salix spp.), dogwood (Cornus spp.) and chokecherry (Prunus virginiana) were present (Fig. 1). Preliminary data on the vegetation of the area showed that shrubs and trees number 32.4 per 100 square meter plot.* Cottonwood was the most abundant of these.

Kentucky bluegrass (Poa pratensis) dominated the understory, with white and small hop clover (Trifolium repens and Trifolium dubium) interspersed. Forbs present included pussytoes (Antennaria spp.), dandelion (Taraxacum officinale), mouse-ear chickweed (Cerastium spp.) and cutleaf coneflower (Rudbeckia laciniata). In the more xeric parts of the area, downy chess brome (Bromus tectorum) and common juniper (Juniperus communis) were present.

The vegetation of the lower section was not burned, had received only light grazing prior to 1958, and none since. The total density of all trees and shrubs in this section was 136.7 individuals per 100 square meter plot. Cottonwood was the most abundant tree, and dogwood

*The information on vegetation was supplied by Kenneth E. Tuinstra, who conducted a concurrent study on the floodplain vegetation of the two study sections.

and willow were the dominant shrubs (Fig. 2). Hawthorn, water birch and alder were also common.

Shade-tolerant grasses and forbs were more abundant here than in the grazed section. Common species included cow-parsnip (Heracleum lanatum), aster (Aster spp.), starry false solomons seal (Smilacina stellata), goldenrod (Solidago spp.), wild licorice (Glycyrrhyza lepidota) and common snowberry (Symphoricarpos albus), and in the more mesic areas, redtop (Agrostis alba). This section is in a more advanced state of plant succession than is the grazed, and the topsoil is better developed.

Throughout the study area the channel lacks most of the characteristics of a meandering stream (Matthes, 1941). The stream bed in both sections was composed mainly of rubble.

Figure 1 - Grazed section, showing low density of shrubs and trees on the flood plain and the sloughing of banks.

Figure 2 - Ungrazed section, showing high density of shrubs and trees on the flood plain, abundance of bank cover, and well-confined channel.

STREAM MORPHOLOGY

Widths

Eroded channel and water (water's edge to water's edge) widths were taken every 50 feet on the main channel. Eroded channel was designated as any area inundated with sufficient frequency to prevent the establishment of stages in plant succession beyond primary colonization.

Widths were taken perpendicular to the main channel current and if side channels were present, their average widths were added to each main channel measurement. All water width measurements were obtained within one week to minimize the effect of fluctuation in discharge. All data on morphology were taken during the summer of 1965.

Additional width data were obtained from a map of the study area (scale 1 inch = 60 feet) made by the Montana Highway Department. The map was constructed from aerial photos (scale 1 inch = 250 feet) using a Kelsh plotter. Table 1 shows that average water widths obtained from the map were less than those from field data. This was probably due to the smaller discharge when aerial photos were made.

Table 1. Eroded Channel and Water Widths of Grazed and Ungrazed Study Sections

	Field Measurements (ft)	Map Measurements (ft)
Eroded Channel Width		
Grazed Section	141	119
Ungrazed Section	103	67
Water Width		
Grazed Section	74	66
Ungrazed Section	66	53

Results of both methods showed that the average water and eroded channel widths were less for the ungrazed section than for the grazed. The difference was most pronounced for eroded channel width. The average widths for field and map measurements in the grazed section were 37.6 percent and 77.3 percent higher than for the ungrazed, respectively. This is probably due to the unstable nature of the banks in the grazed section and their greater erodability (Fig. 1).

Water Types

The stream was visually classified into three water types--riffle, run and pool. Several trial classifications were made to delineate more or less uniform blocks of each water type. The following criteria were used to characterize the types:

Riffle - Average depth usually not more than 15 inches, water velocity high and surface choppy.

Run - Average depth usually more than 15 inches, but deeper parts less than 30 inches, water velocity high to intermediate and surface generally choppy.

Pool - Average depth usually more than 15 inches, but deeper parts more than 30 inches, water velocity low and surface smooth.

After the stream had been classified a final time, the length of each block was recorded and width and depth measurements were taken near its upper end, middle and lower end. Depths were taken at three-foot intervals across the channel.

Fluctuations in water level occurred during the classification, but their effect on comparison of the ungrazed and grazed sections was

reduced, as a similar proportion of each section was classified at a given water level.

The total length and area of water classified was 6,779 feet and 205,779 square feet, respectively, for the grazed section and 9,676 feet and 279,498 square feet for the ungrazed. On the basis of length and area, there was a greater percentage of runs and pools and a lower percentage of riffles in the ungrazed than in the grazed section (Table 2).

Average length and area of riffles and pools was greater in the grazed than in the ungrazed section, while the opposite was true for runs. The number of riffles per 1,000 feet of stream was about the same for the grazed section (5.3) as for the ungrazed (5.6), while runs and pools were, respectively, about 2 and 1.6 times more frequent in the ungrazed section. These data show a more frequent subdivision and interspersion of water types for the ungrazed section than for the grazed.

The average depth of each section was obtained by weighting the average depth of each water type for area covered in that section as follows:

$$\text{depth} = \frac{(a_1)(d_1) + (a_2)(d_2) + (a_3)(d_3)}{a_1 + a_2 + a_3}$$

where a_n = area of water type in section
d_n = average depth of water type

Average depth was 1.34 feet in the ungrazed section and 1.06 in the grazed.

Cover

Individual "units" of cover were classified as undercut banks, debris, overhanging brush and miscellaneous cover. Debris consisted of dead snags, branches and twigs that had become lodged in the stream channel. Rooted plants with boughs a foot or less above the water's surface were classified as overhanging brush. Miscellaneous cover included large rocks, aquatic vegetation, etc.

Debris comprised 60 percent of the total cover in the grazed section and 70 percent in the ungrazed (Table 3). Undercut banks were next in importance, with overhanging brush and miscellaneous cover together comprising only about 10 percent of the cover for each section.

The greatest differences in cover between the two sections occurred in riffle areas. Although the grazed section had the highest percentage of riffles (77 percent by area), a lower percentage of the cover there was associated with riffles, a higher percentage with pools and a similar percentage with runs,as compared to the ungrazed.

Cover in the grazed section was somewhat restricted to the deeper water types, but was more uniformly distributed in the ungrazed section. This is because the areas surrounding the stream in the grazed section are more susceptable to erosion. The results of the erosion were most pronounced in the riffle areas where wide expanses of gravel dominate much of the stream side (Fig. 3).

The amount of cover per acre of stream was 76.4 percent higher in the ungrazed section than in the grazed. Most of this difference was due to debris and overhanging brush, as both showed two-fold increases

Table 2. Extent, Average Depth and Frequency of Water Type for Grazed and Ungrazed Study Sections

		Avg. Depth (ft)	No.	Total Length (ft)	Avg. Length (ft)	% of Total Length	Total Area (ft^2)	Avg. Area (ft^2)	% of Total Area
Riffle	Grazed	.80	36	5,314	148	78.4	158,867	4,413	77.2
	Ungrazed	.87	54	5,201	96	53.8	121,215	2,245	43.4
Run	Grazed	1.66	10	606	61	9.0	17,507	1,751	8.5
	Ungrazed	1.50	30	2,694	90	27.8	105,169	3,506	37.6
Pool	Grazed	2.10	13	859	66	12.0	29,405	2,262	14.3
	Ungrazed	2.07	30	1,781	59	18.4	53,114	1,771	19.0

Table 3. Extent of Cover in Relation to Water Type for Grazed and Ungrazed Study Sections

	Grazed					Ungrazed				
	Pools (ft^2)	Riffles (ft^2)	Runs (ft^2)	% Total Cover	Total/ Stream Acre	Pools (ft^2)	Riffles (ft^2)	Runs (ft^2)	% Total Cover	Total/ Stream Acre
Undercuts	1,121	305	1,525	28.5	653	1,863	916	1,801	17.6	712.3
Debris	2,374	2,937	959	60.6	1,388	4,940	9,120	4,261	70.6	2849.3
Overhanging Brush	84	319	120	5.1	116	562	1,371	643	9.9	400.6
Miscellaneous	442	13	160	5.8	132	168	153	160	1.9	74.8
Total	4,001	3,574	2,764	100.0	2,289	7,533	11,560	6,865	100.0	4037.0
% of Total Stream Area	38.7	34.6	26.6			29.0	44.5	26.5		

Figure 3 - Grazed section showing the advanced state of erosion and wide channel.

over grazed section values. The amount per acre of undercut bank was little different between sections, and miscellaneous cover was most abundant in the grazed section.

FISH POPULATION

Population Estimates

The fish population of each study section was censused from September 1 through 26, 1964 with a 300 volt, 850 watt direct current shocker. An attempt was made to estimate the total fish population using the Petersen type mark and recapture method (Ricker, 1958). A single downstream collection pass was made through the entire length of each section. Captured fish were weighed to the nearest .02 pound, measured for total length to the nearest 0.1 inch, fin-clipped and returned to their approximate point of capture. About one week later each section was reshocked and lengths were secured for all fish captured.

The amount of the stream shocked in 1964 was less than the amount classified in 1965 due to lower water levels. Several small channels in both sections contained little or no water in 1964. About 5,219 feet and 187,131 square feet of stream in the grazed and 8,026 feet and 268,266 square feet in the ungrazed section were censused.

Fish present in the study area, in order of abundance, included brown trout (Salmo trutta), brook trout (Salvelinus fontinalis), mountain sucker (Pantosteus platyrhynchus), mountain whitefish (Prosopium williamsoni), longnose sucker (Catostomus catostomus), rainbow trout (Salmo gairdneri) and longnose dace (Rhinichthys cataractae). One white sucker (Catostomus commersoni) and an unidentified cyprinid were found.

Species other than brown trout comprised about 9 percent of the total number and 21 percent of the total weight of fish captured a first time. No population estimates were made for these species (Table 4).

Brook trout accounted for 60 percent of all fish other than brown trout. The number per acre in the grazed section was 67 percent greater than in the ungrazed, but the weight per acre was only slightly higher. This was due mainly to the larger number of brook trout over four inches in the ungrazed section (16 percent) than in the grazed (6 percent).

Whitefish and longnose suckers comprised about 28 percent and 43 percent, respectively, of the total weight per acre of species other than brown trout. The weight for whitefish in the ungrazed section was 18 percent greater than in the grazed section, while for longnose suckers it was about three times greater.

The number per acre of fish other than brown trout was 31 percent greater in the grazed section than in the ungrazed, but the weight per acre was 53 percent greater in the ungrazed section.

Brown trout were grouped in six size classes for the computation of Petersen estimates, since differential efficiency for capture of large and small fish has been reported by Shetter, et al. (op. cit.) and by Cooper and Lagler (1952). For each estimate, 95 percent confidence intervals were constructed using Clopper and Pearson's (1934) tables. If sample size was over 1,000, confidence limits were computed directly using an equation based on formula 3.6 of Ricker (op. cit.).

Table 4. The Number and Weight per Acre of Fish Exclusive of Brown Trout from Grazed and Ungrazed Study Sections

	Number		Pounds	
	Grazed	Ungrazed	Grazed	Ungrazed
Brook Trout	146.7	87.9	3.8	3.5
Mountain Sucker	28.8	27.1	3.9	3.1
Mountain Whitefish	23.7	13.1	8.4	9.9
Longnose Sucker	7.0	23.5	7.0	21.7
Rainbow Trout	10.2	5.2	3.0	1.4
Longnose Dace	1.0	9.1	.1	.4
TOTAL	217.4	165.9	26.2	40.0

The number and weight of brown trout per acre in the ungrazed section was greater than in the grazed for all size classes except the smallest (Table 5). Brown trout 2.0 to 3.9 inches long were 3 percent more abundant per acre in the grazed section than in the ungrazed. The number and weight per acre of fish six inches or longer were 27 percent and 44 percent greater, respectively, in the ungrazed section.

Thirty-four brown trout over 14 inches long were captured in the ungrazed section and the largest was 22.2 inches long and weighed 3.84 pounds. In the grazed section, only 10 brown trout over 14 inches were taken, the largest was 16.5 inches long and weighed 1.54 pounds.

The total number of brown trout per acre was similar for both study sections, but weight per acre was 31 percent greater in the ungrazed section.

The total estimated pounds of fish per acre was 140.7 in the grazed section and 190.3 in the ungrazed. Trout comprised 121.3 pounds of the total in the grazed section and 155.2 pounds in the ungrazed.

Age and Growth

A stratified subsample of scales from 250 brown trout was collected from each section. Scale annuli were identified with the aid of a projection machine. Total lengths were obtained through use of a nomograph, assuming a linear relationship between scale and body length. Scales from most trout over 12 inches long were regenerated or so badly eroded that annuli could not be detected.

No great difference in brown trout growth rate was apparent between the two sections (Table 6). Hence, the greater weight of brown trout

Table 5. Population Estimates of Brown Trout in the Grazed and Ungrazed Study Sections with 95% Confidence Limits on Total Number Estimates

Total Length (inches)		Population Estimate	Confidence Interval	Estimated No./Acre	Estimated Lbs/Acre
2.0-3.9	Grazed	8,244	7,896- 8,592	1,918	34.9
	Ungrazed	11,527	11,267-11,787	1,868	34.1
4.0-5.9	Grazed	228	205- 258	53	3.3
	Ungrazed	629	594- 676	102	6.2
6.0-7.9	Grazed	942	902- 1,009	219	24.2
	Ungrazed	1,535	1,517- 1,553	249	26.9
8.0-9.9	Grazed	287	269- 312	67	18.4
	Ungrazed	521	500- 550	84	20.6
10.0-11.9	Grazed	200	187- 221	46	21.1
	Ungrazed	448	430- 470	73	32.0
12 & Over	Grazed	68	61- 84	16	12.6
	Ungrazed	220	205- 242	36	30.5
TOTAL	GRAZED	9,969	9,614-10,324	2,319	114.5
	UNGRAZED	14,880	14,613-15,147	2,412	150.3

per acre in the ungrazed section was due to the greater number of fish in the larger size classes, rather than to a higher growth rate.

Table 6. Average Calculated Total Lengths of Brown Trout from the Two Study Sections

Age Group	No. of Fish		Total Length (inches) Year of Life 1	2	3	4
		Grazed Section				
I	71		3.5			
II	43		3.4	7.1		
III	30		3.8	7.3	9.9	
IV	7		3.6	7.5	9.9	12.7
Total	151	Average	3.5	7.2	9.9	12.7
		Ungrazed Section				
I	73		3.4			
II	44		3.5	7.2		
III	28		3.5	6.9	9.7	
IV	11		3.8	7.0	10.2	13.1
Total	156	Average	3.5	7.1	9.8	13.1

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