Physical factors influencing fish populations in pools of a trout stream
by Stephen Lawrence Lewis

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
Montana State University

Abstract:
The relationship between physical parameters and fish populations of 19 pools of Little Prickly Pear Creek, Montana, was studied during the summers of 1965 and 1966. The pools were mapped and their fish populations sampled. Differences in surface area, volume, average depth, average current velocity, total cover and percent cover accounted for 75, 77 and 70 percent of the variation in numbers of total trout, brown trout and rainbow trout respectively. Current velocity and total cover were the most important factors, and together they accounted for most of the explained variation. Each of these two factors contributed significantly to total trout numbers. Cover was the most important factor for brown trout, and current velocity was most important for rainbow trout. The number of trout per unit of cover (cover quality) and the number per unit of pool surface area (pool quality) increased significantly as current velocity became greater. Deep-slow pools with a large amount of cover had the most stable populations with brown trout being more stable than rainbow trout. Suckers were most common in large, deep-slow pools with extensive cover. The importance of cover to trout is discussed in terms of security and photonegative response, and current velocity in terms of space-food relationships.

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ABSTRACT

The relationship between physical parameters and fish populations of 19 pools of Little Prickly Pear Creek, Montana, was studied during the summers of 1965 and 1966. The pools were mapped and their fish populations sampled. Differences in surface area, volume, average depth, average current velocity, total cover and percent cover accounted for 75, 77 and 70 percent of the variation in numbers of total trout, brown trout and rainbow trout respectively. Current velocity and total cover were the most important factors, and together they accounted for most of the explained variation. Each of these two factors contributed significantly to total trout numbers. Cover was the most important factor for brown trout, and current velocity was most important for rainbow trout. The number of trout per unit of cover (cover quality) and the number per unit of pool surface area (pool quality) increased significantly as current velocity became greater. Deep-slow pools with a large amount of cover had the most stable populations with brown trout being more stable than rainbow trout. Suckers were most common in large, deep-slow pools with extensive cover. The importance of cover to trout is discussed in terms of security and photonegative response, and current velocity in terms of space-food relationships.

INTRODUCTION

An important environmental requirement of trout in streams is shelter, generally associated with pools. Several workers have shown the value of overall habitat quality in relation to trout population levels in sections of streams. The stream improvement work of Tarzwell (1937, 1938); Shetter, Clark and Hazzard (1946); and Saunders and Smith (1962) showed that population levels respond to an increase in shelter and food. Gunderson (1966) found that an ungrazed stream section with higher percentages of deep water types and more cover had a population of brown trout (over 6 inches long) that was 27 and 44 percent greater by number and weight respectively than a grazed section of the same stream with shallower water and less cover. Boussu (1954) showed that removal of undercut banks and brush in a section of stream caused a decrease in numbers and weight of trout, with decreases being greatest for larger fish. Shuck (1945) reported that volume and depth of water were significant factors in determining the population density of larger brown trout in a section of stream.

The social behavior of fish in relation to habitat conditions is an important consideration. The investigations of Kalleberg (1958) and Newman (1956) showed that salmonids are territorial and establish a social hierarchy within the overall population. Thus there is competition for the limited number of favorable positions within a stream. This indicates population levels may be self-limiting based on the quality of the habitat.

I evaluated the physical aspects of habitat quality of pools on Little Prickly Pear Creek, Montana, from July, 1965, to September, 1966. The objectives were to determine: (1) which physical factors were most important in determining standing crops of fish and (2) population stability.

DESCRIPTION OF THE STUDY AREA

Little Prickly Pear Creek is a small trout stream located 30 miles northwest of Helena, Montana. This stream arises on the east slope of the continental divide approximately 4,600 feet above sea level and flows northeasterly for about 35 miles. It enters the Missouri River 3 miles downstream from Wolf Creek, Montana, at an elevation of 3,300 feet. The drainage basin encompasses an area of 394 square miles consisting primarily of grassland slopes with open stands of conifers. Analyses done by the Soil Conservation Service show that the soils of the drainage basin are weakly calcareous, being derived mainly from weathered argillite rock with smaller contributions from weathered quartzite and igneous rocks.

The study area included 16 pools and a 940 foot section of stream referred to as the stability area. The latter contained three pools and the interconnected riffles above each pool. All pools were within a 6.2 mile length of stream from 0.7 mile above the mouth of Trinity Creek to 0.2 mile below the mouth of Big Sheep Creek (Figure 1).

Little Prickly Pear Creek is a mountain stream with high flows during the spring runoff and low flows during the summer, fall and winter. Flow data from the Sieben Gage Station indicate the peak of the spring runoff generally occurs in May with mean monthly discharge ranging from 70.2 to 354.0 cfs. Low summer flows occur in August with the mean monthly discharge varying from 11.5 to 51.7 cfs. Water conditions during the study period varied from high water in 1965 to more normal flows in 1966. The mean monthly discharges at the Sieben Gage Station for July, August and

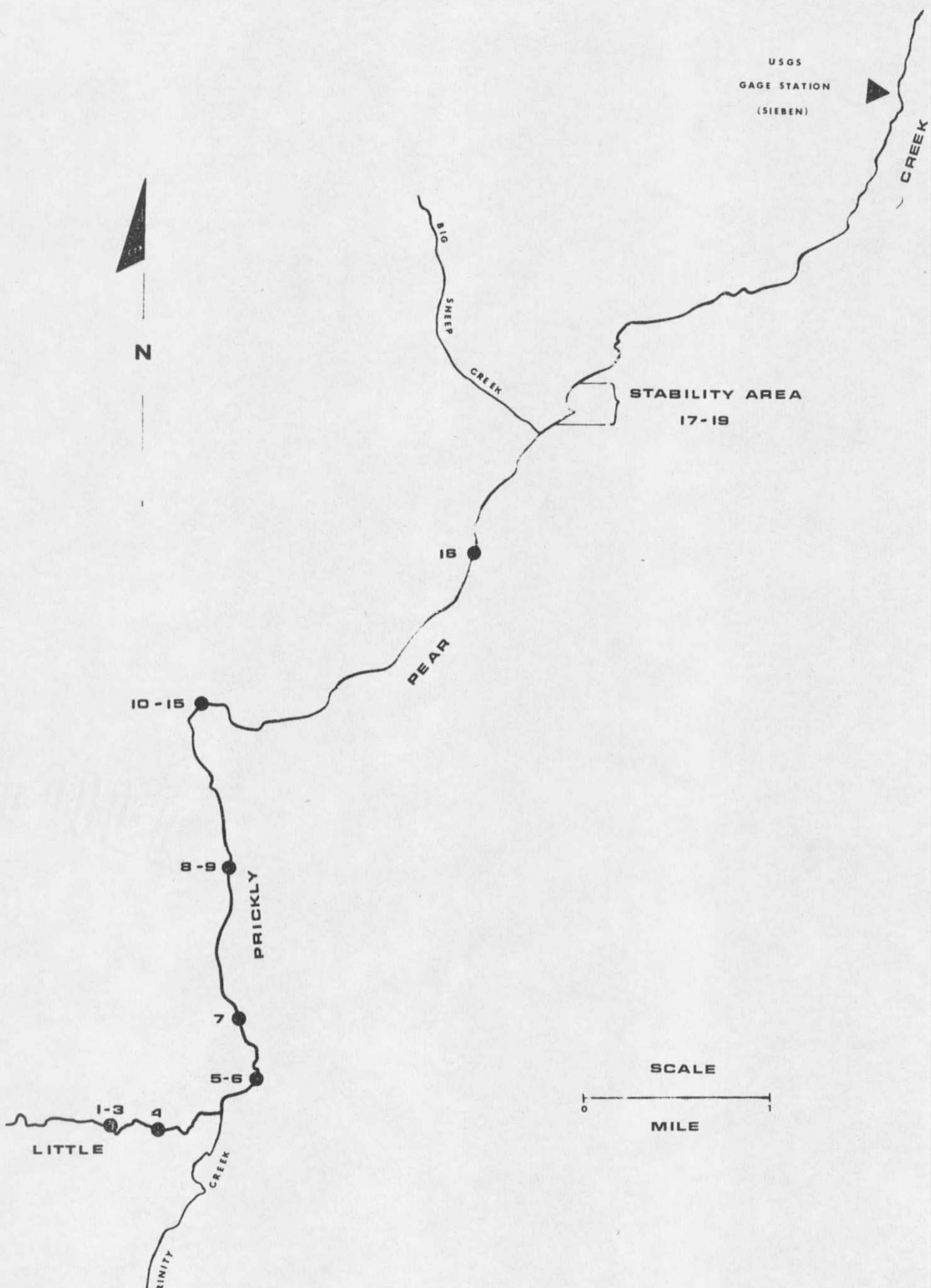

Figure 1. Study area of Little Prickly Pear Creek showing the approximate location of pools and the stability area.

September, 1965, were 92.2, 51.7 and 85.5 cfs respectively; and for 1966, 33.4, 14.1 and 20.4 cfs respectively. During periods of low flow, stream widths averaged from 20 to 30 feet with depths in most pools not exceeding 5 feet. Discharge and stream size increased progressively downstream.

Chemical analyses were made during the summers of 1965 and 1966 in the section of stream from the mouth of Canyon Creek to the Sieben Gage Station. Alkalinity ranged from 3.9 to 4.9 milliequivalents per liter, pH from 7.6 to 8.7, conductivity (K_{25}) from 350 to 445 micromhos, and total hardness from 210 to 235 ppm. Mean monthly temperatures for July, August and September, 1962-65, at the Sieben Gage Station ranged from 41.0 to 64.7 F (Swedberg, 1965).

The species of fish taken in the study area in order of decreasing abundance were: brown trout (Salmo trutta), longnose sucker (Catostomus catostomus), rainbow trout (Salmo gairdneri), mountain whitefish (Prosopium williamsoni), brook trout (Salvelinus fontinalis) and white sucker (Catostomus commersoni). Mottled sculpin (Cottus bairdi), although numerous, were not considered in this study. There has been no stocking of fish in the stream since 1954.

METHODS

For purposes of this study a pool was defined as any relatively large stream area capable of providing shelter for larger fish. The pools ranged from deep-slow portions of the stream to areas of shallow-fast water associated with cover. Physical characteristics used to select pools were size (surface area), depth, current velocity and cover. Pools selected were distinct units, limited above and below by the presence of shallow water types without cover. This minimized the error of over-lapping home territories of fish from adjacent pools.

All pools were mapped between August 9 and September 12, 1966, at a low stabilized flow of 16 to 32 cfs. Transects were established at 10-foot intervals and depths were taken every foot along each transect. Current velocities were measured with a Gurley current meter at 0.4 of the observed depth every 2 feet along each transect. The water comprising a pool was classified into types based on depth and current velocity (Table 1). Cover was mapped and this included brush, overhanging vegetation, undercut banks and miscellaneous types. The term brush was used to describe dead submerged woody portions of bank vegetation occasionally

Table 1. Criteria of water-type classification

Water type	Depth (feet)	Current velocity (feet per second)
Slow-Shallow (SS)	0.1-1.5	-1.00
Deep-Slow (DS)	+1.5	-1.00
Shallow-Fast (SF)	0.1-1.5	+1.00
Deep-Fast (DF)	+1.5	+1.00

strengthened by live growth. Overhanging vegetation was live growth that provided an overhead canopy less than one foot above the water's surface. Miscellaneous cover included underwater shelves provided by clay and rock, tree roots and debris. Pool boundaries were delineated by depth and cover. The surface area included within the pool was deeper than 1.4 feet and areas with cover regardless of depth. Surface area, water-type composition and extent of cover were determined with a planimeter from the maps. Average depth, average current velocity and pool volume were calculated for each pool. Figure 2 is a representative pool map showing water types, cover and the pool boundary.

The fish populations of all areas were sampled between August 3 and September 1, 1965, and between July 11 and July 27, 1966. Discharges at the time of fish sampling in 1965 ranged from 37 to 73 cfs compared with 28 to 43 cfs in 1966. The stability area was also sampled December 20, 1965, and April 1, 1966. Sampling was done by electrofishing using a 300 volt, 850 watt direct current unit. Individual pools were isolated with blocking nets and at least three passes were made through each area. Captured fish were anesthetized with MS-222 (Tricaine Methanesulfonate), measured to the nearest 0.1 inch total length and weighed to the nearest 0.01 pound. Trout from 7.0 to 8.0 inches long or longer were tagged with plastic band jaw tags. Whitefish were tagged with metal opercle tags and suckers with plastic dart tags inserted at the base of the dorsal fin. Trout smaller than 4.0 inches and whitefish and suckers smaller than 7.0 inches were not included in this study since they were seldom present in the pools sampled.

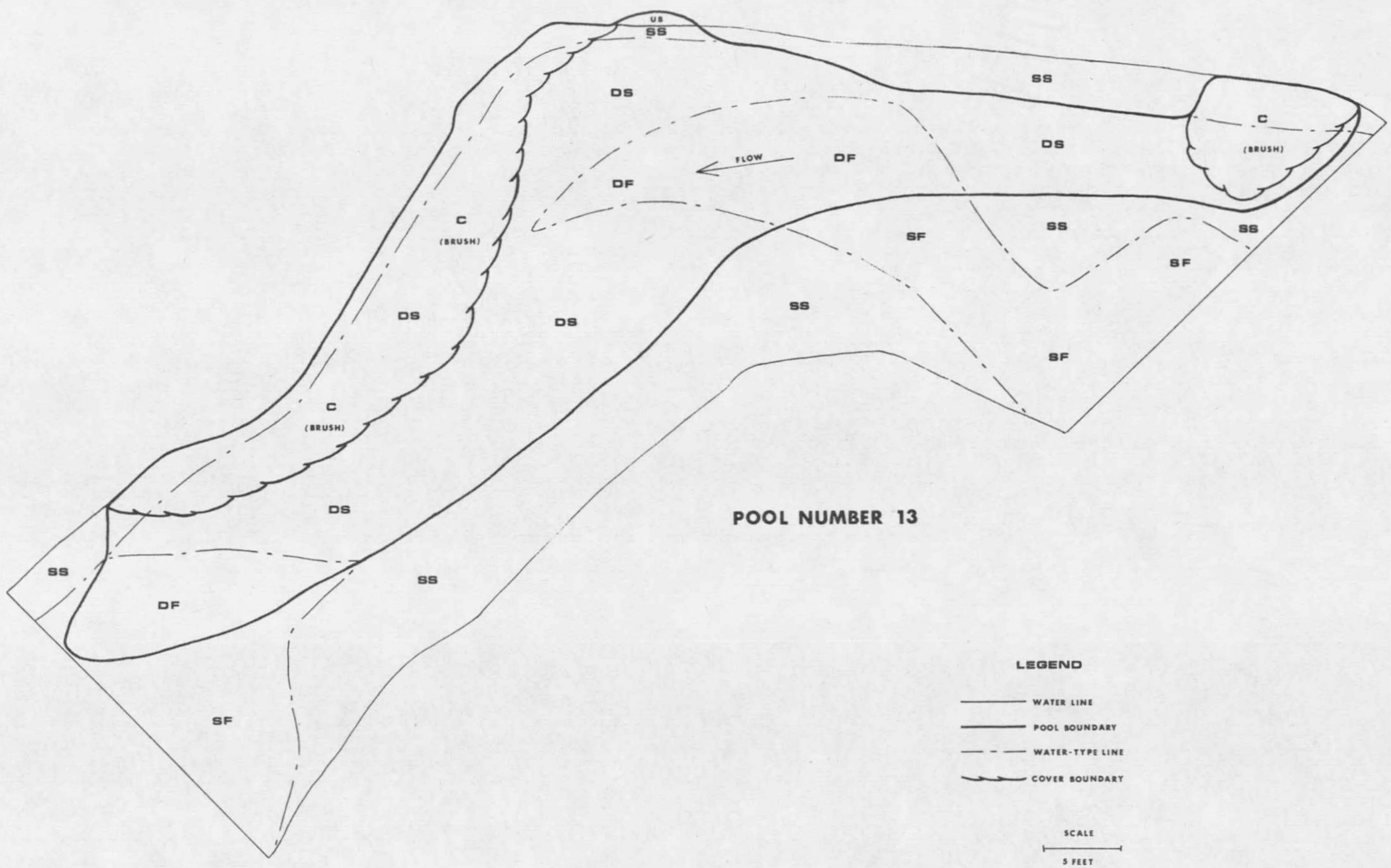

Figure 2. Representative pool map showing water types, cover and pool boundary.

The efficiency of fish sampling (ratio of marked to unmarked in a second sample) was determined in the stability area and a large pool. Trout 4.0 to 6.9 inches had a range of 72 to 78 percent while those 7.0 inches and over had a range of 84 to 100 percent. Sampling efficiency for suckers was 56 percent. There were too few whitefish present for efficiency determination. Elser (1967) with more extensive sampling in the same general stream section had similar efficiencies.

The data were analyzed in a multiple linear regression and analysis of variance according to Bailey (1959) and Snedecor (1956) to determine the relationships between physical parameters and fish populations of pools.

RESULTS

Physical Parameters of Pools

Physical data for pools are presented in Table 2. Pools ranged in surface area from 273.9 to 1,849.3 square feet with volumes from 593.4 to 4,068.5 cubic feet. Average depths varied from 1.3 to 2.5 feet and average current velocities from 0.30 to 1.67 f.p.s. (feet per second). The predominant water type was deep-slow in 14 pools, deep-fast in 4 pools and slow-shallow in 1 pool. The slow-shallow pool also had a high percentage of fast water types. Slow-water pools were generally deep, and/or large, and often located on sharp bends of the stream (Figures 3 and 4). Fast-water pools were smaller, shallower and associated with straight stream channels (Figures 5 and 6).

Cover ranged as high as 496.8 square feet and made up as much as 51.7 percent of the pool surface area. Larger pools generally contained more cover than smaller pools. Brush made up 77.0 percent, undercut banks 10.6 percent, overhanging vegetation 7.3 percent and miscellaneous types 5.1 percent of all pool cover. The important plant species constituting cover were willow (*Salix* sp.) and dogwood (*Cornus* sp.).

Fish Populations of Pools

Trout 4.0 to 6.9 inches were primarily yearling fish (Bishop, 1955; Elser, 1967). These comprised 27 percent of the trout sampled in 1965 and 39 percent in 1966 but less than 7 percent of the weight in either year. Since the pools selected were not considered the primary habitat of small trout and since their abundance did not correlate with pool