Initial effects of streambank stabilization on a small trout stream
by Walter Virgil McClure

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
In a 1.4-km study area of Deep Creek, Montana, during spring 1988, the badly eroded outer (current-bearing) banks of six stream bends were revetted with rock (riprap), six similar banks were revetted with juniper trees, and six such banks were left untreated as controls. Before and after treatment, physical variables of the stream were measured and the trout population was inventoried. Hiding cover for trout changed significantly 8 months after treatment: a mean increase of 195% in bends revetted with trees and a mean decrease of 36% in riprapped and control bends. In that period, no significant changes had developed in amount of pool habitat, in channel width, or in water depth. Stock densities and standing crops of brown and rainbow trout >20 cm long decreased throughout the study area due to drought and irrigation dewatering, but abundance of trout <10 cm long recovered to pre-treatment levels by October 1988 in tree-revetted and control bends. Stock densities of trout decreased significantly in riprapped bends between March and June 1988. There were no significant differences in abundance of trout between the two treatments or the treatment and control bends during March, June, and October 1988. Extreme low flow affected trout populations more than the habitat manipulations.

The main source of streambank erosion observed was mass wasting fracture caused by attached ice shelves during spring thaw. Riprap and tree revetment provided structural integrity and greatly reduced such erosion. Stabilizing streambanks with tree revetments has advantages over riprap because it immediately increases hiding/security cover for trout, traps sediment which serves as soil for natural reestablishment of live vegetation, and eventually decomposes allowing restoration of more natural and functional streambanks.

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APPROVAL

of a thesis submitted by

Walter Virgil McClure

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date *May 16, 1991*

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ABSTRACT

In a 1.4-km study area of Deep Creek, Montana, during spring 1988, the badly eroded outer (current-bearing) banks of six stream bends were revetted with rock (riprap), six similar banks were revetted with juniper trees, and six such banks were left untreated as controls. Before and after treatment, physical variables of the stream were measured and the trout population was inventoried. Hiding cover for trout changed significantly 8 months after treatment: a mean increase of 195% in bends revetted with trees and a mean decrease of 36% in riprapped and control bends. In that period, no significant changes had developed in amount of pool habitat, in channel width, or in water depth. Stock densities and standing crops of brown and rainbow trout ≥20 cm long decreased throughout the study area due to drought and irrigation dewatering, but abundance of trout <10 cm long recovered to pre-treatment levels by October 1988 in tree-revetted and control bends. Stock densities of trout decreased significantly in riprapped bends between March and June 1988. There were no significant differences in abundance of trout between the two treatments or the treatment and control bends during March, June, and October 1988. Extreme low flow affected trout populations more than the habitat manipulations. The main source of streambank erosion observed was mass wasting fracture caused by attached ice shelves during spring thaw. Riprap and tree revetment provided structural integrity and greatly reduced such erosion. Stabilizing streambanks with tree revetments has advantages over riprap because it immediately increases hiding/security cover for trout, traps sediment which serves as soil for natural reestablishment of live vegetation, and eventually decomposes allowing restoration of more natural and functional streambanks.

INTRODUCTION

This study was undertaken to evaluate physical and biological effects of two methods of reinforcing stream banks against erosion: revetment with rock (riprap) and with trees. Streambank erosion is a natural process, the rate of which can be influenced by human activities or natural events that change interrelated variables controlling channel shape (Heede 1986; Henderson 1986; White 1973). Where streambank erosion occurs, people often take actions to counter it for protection of property and resource values (Rosgen and Fittante 1986).

Riprap is a common method for stabilizing banks. If properly constructed, riprap not only retards erosion, but also creates overhead hiding and resting niches for trout (White and Brynildson 1967; Binns 1986), provides habitat for benthic invertebrates (Henderson and Shields 1984), and causes deepening of pools (British Columbia Ministry of Environment 1980). Deeper pools benefit trout (Elser 1968). In Huff Creek, Wyoming, trout abundance increased from 36 to 436 trout per mile (1100%) after 3,760 feet of eroding streambanks were stabilized with riprap, check dams and other instream structures (Pistono 1986). In the

Upper Mississippi River, Farbee (1986) found more warmwater fish in areas loosely revetted with stones than in areas revetted with tightly placed smaller stones. Thurow (1987), however, reported lower densities of rainbow trout in riprapped sections than in unaltered sections of the Big Wood River, Idaho.

White and Brynildson (1967) recommended that felled trees be used as trout cover and to stabilize current-bearing stream banks. They described methods they had observed, envisaged, or that had been described by others (R.J. White, pers. commun. 1989). Later, this general method was further developed in the field by various agencies, particularly the U.S.D.A. Forest Service (Pistono 1986).

Tree revetment is now widely used to stabilize streambanks, to provide cover for trout, and to cause silt deposition as sites for willow establishment along banks (Sheeter and Claire 1989). Binns (1986) recommends using green, thickly branched conifers because they provide maximal silt trapping, suitable cover for trout, and attachment surfaces for benthic macroinvertebrates. Pistono (1986) found that tree revetments increased trout habitat quality and trout numbers in Wyoming streams. Sheeter and Claire (in Reeves and Roelofs 1982) reported that whole juniper trees halted bank erosion in Oregon.

The objective of this study was to evaluate changes in physical characteristics of the stream provided by riprap and tree revetments and responses of the trout population to these changes. The hypothesis was that the revetments would provide cover for fish and would narrow and deepen the stream channel, thus improving habitat and leading to greater trout abundance.

DESCRIPTION OF STUDY AREA

Deep Creek, which flows through Broadwater County in central Montana, originates on the north slope of Grassy Mountain in the Big Belt range. It flows westward about 36 km to the Missouri River, 4 km south of the town of Townsend. In this area, average annual precipitation during 1978 to 1988 was 34 cm, most of which occurred between February and June. However, for 1987 and 1988, these amounts were only 19 and 25 cm, respectively. There were irrigation diversions upstream from the study area, which severely reduced the amount of water in the stream each summer.

The study area comprised about 1,400 m of the creek in Section 2, Township 6 North, Range 2 East (Figure 1) on a ranch that was owned by Mr. and Mrs. Ray Goodwin of Helena, Montana, until the winter of 1988-89, when it was bought by the Leslie L. Schipman family. When the study began in 1986, the ranch was run as a grain farm by the Goodwins' daughter and son-in-law, after having been converted from a cattle operation about three years before.

This part of the stream had been chosen in 1984 as a study area because many of the current-bearing (outer or concave) banks of its meander bends were high, steep, and composed of raw soil. The site was also chosen because the riparian area was not grazed by livestock. On both sides of the stream, fences paralleled the approximate mean alignment of the channel. The fences were about 90 m apart and in most places were well outside the riparian

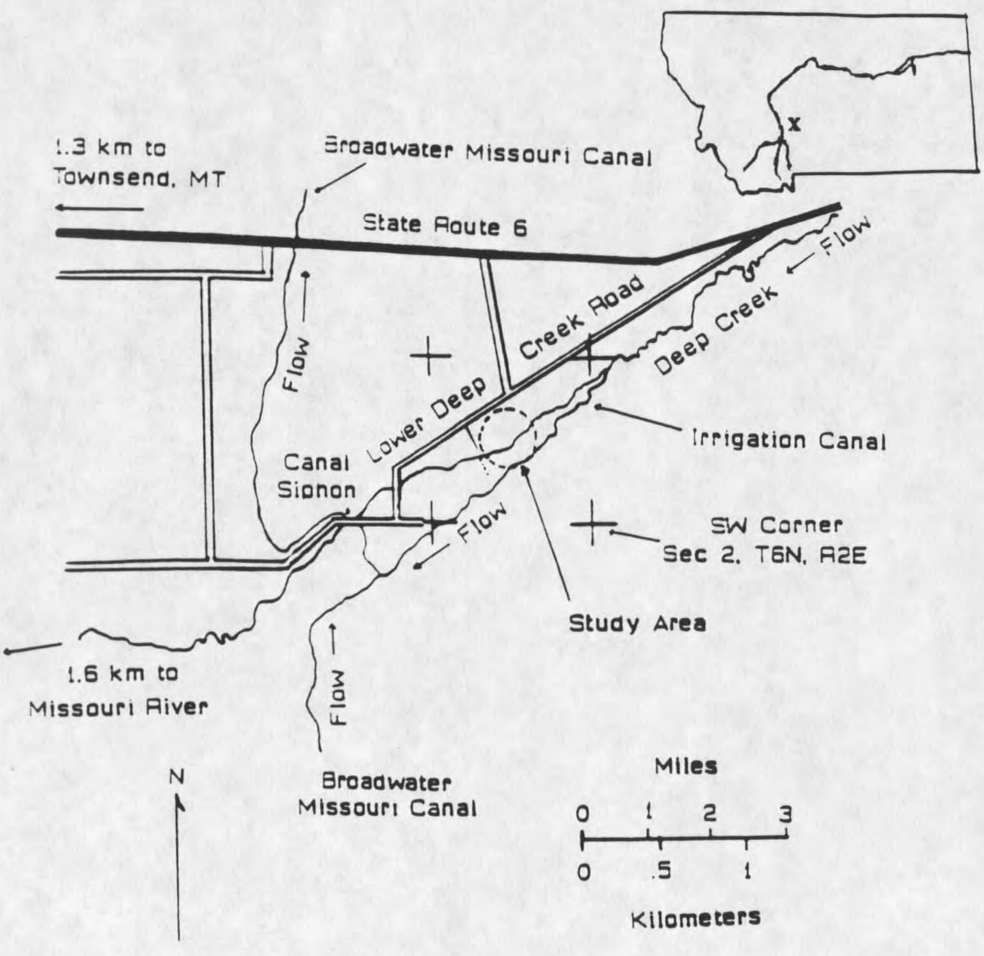

Figure 1. Location of Deep Creek study area relative to local features.

vegetational zone. At one bend, the channel had migrated laterally to within two meters of the fence. Had the stream not become incised (probably due to grazing and other human influence) and had it retained its natural form, the riparian vegetational zone probably would have been wider than the area bounded by the fences. The area between the fences had not been used as pasture since about 1983.

The tops of most of the high, eroded banks were vegetated with orchard grass (Dactylis glomerata) and smooth brome (Bromus inermus). The inside (convex) banks usually were lower, had moister soils, and had thickets of brush upslope from the point bars of gravel or other sediment. Woody vegetation in the study area included willows (Salix sp.), dogwood (Cornus stolonifera), water birch (Betula occidentallis), common snowberry (Symphoricarpos albus) and black cottonwood (Populus trichocarpa).

The stream's water was apparently rich in nutrients. A thick, limey crust and algal growth covered the streambed rocks.

The fish population of Deep Creek included rainbow trout (Oncorhynchus mykiss), brown trout (Salmo trutta), mountain whitefish (Prosopium williamsoni), longnose dace (Rhinichthys cataractae) and sculpin (Cottus sp.).

METHODS

General Approach

The centerline length of the channel was measured and the study area marked off into 100-m reference stations. The reference stations were numbered from 0 at the lower end to 14 at the upper end. Each 100-m "station" segment was identified by the number of the marker at its upper end. Mean wetted width of each station was determined by averaging waterline-to-waterline measurements made at 10-m intervals during streamflow discharge of about 285 L/s.

In August 1987, 18 channel bends that had areas of highly eroded, current-bearing banks were located and assigned numbers. The up- and downstream limits of the erosional or current-bearing zone of each of these bends were marked with stakes and the channel centerline length of each was measured. Six of the bends were selected to be revetted with riprap, six were selected for revetment with cabled trees, and six were assigned as untreated controls (Figure 2). A random method was used for this selection, except that the two bends farthest upstream were designated as controls, so that at least two sites would remain unaffected by sediments that might flow from treatments.

During April and May 1988, riprap (236 m total length) and juniper-tree revetment (211 m total length) were installed on the banks designated for these treatments. The six control bends contained 219 m of current-bearing bank (Table 1). To monitor changes, fish populations and physical characteristics of the 18 channel bends were measured before and after treatment.

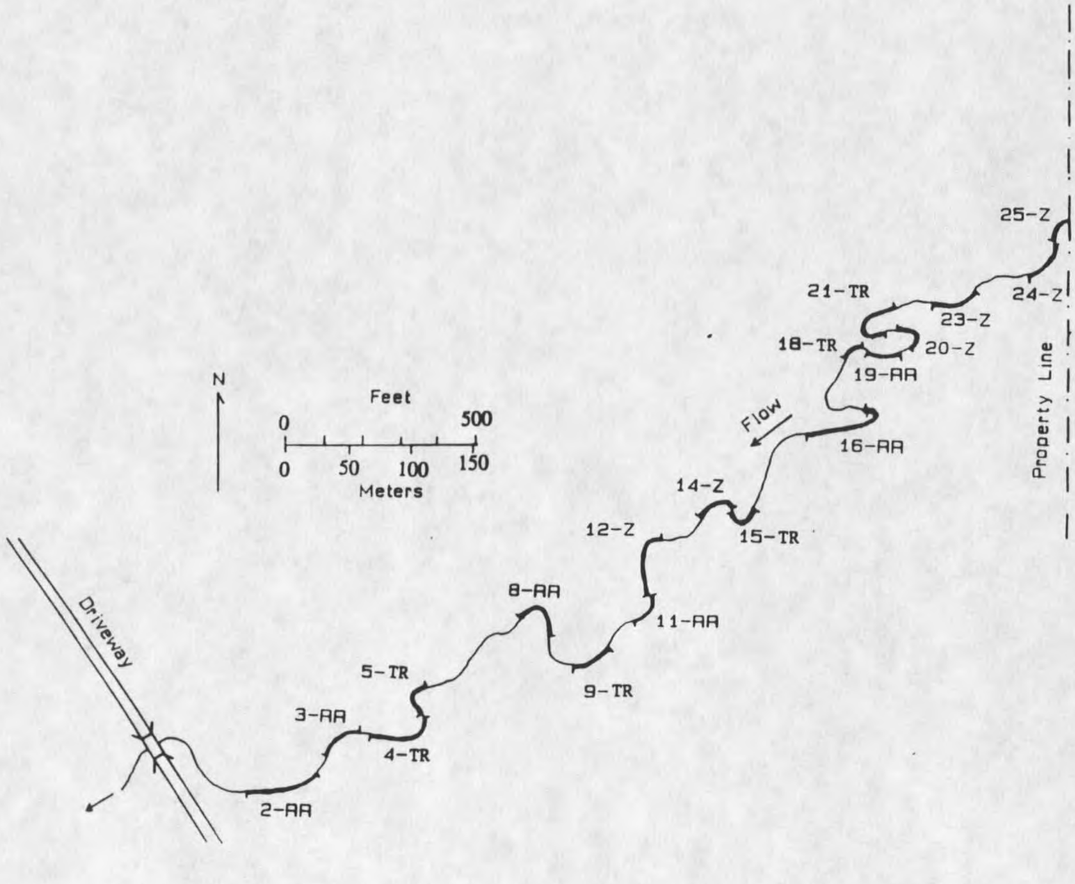

Figure 2. Deep Creek study area, numbers refer to stream bends studied RR = riprap, TR = tree revetment, Z = control.

Table 1. Treatment and length of study bends in the 1.4-km study area of Deep Creek, Montana.

Treatment Bend	Length (m)
Tree Revetment	
4	60
5	32
9	28
15	43
18	14
21	34
Riprap	
2	60
3	29
8	50
11	29
16	46
19	22
Control	
12	68
14	23
20	20
23	58
24	29
25	21

Construction of Revetments

Riprap

In April 1988, the current-bearing banks of bends 2, 3, 8, 11, 16, and 19 were riprapped with angular (blast-quarried) limestone from the Continental Lime Company quarry west of Townsend. The stone was selected in consultation with Dr. David W. Mogk, Montana State University Earth Sciences Department. Dr. Mogk had special expertise in determining suitability of rock for construction purposes, including riprap. The limestone was of a hard, fine-grained structure considered by Dr. Mogk to have low water absorption, hence low susceptibility to freeze-shattering.

The steps in riprap construction were as follows: (1) uneven or overhanging parts of the bank were sloped back to about a 1:1 to 1:1.5 grade with a backhoe; (2) rocks of about 1 m diameter were placed on the stable (armored) stream bed along the toe of the bank; and (3) smaller (ca. 20-80 cm) rocks were arranged blanket-fashion along the length of the bank above this foundation. Finished face slope of the riprap was about 1:1 to 1:2, except that the large rocks at the toe of each structure formed a much steeper (or overhanging) and very irregular face. The riprap blankets were 1 m or more in thickness at the base and tapered to about 0.5 m thickness near the top of the bank (Figures 3 and 4).

Although it is standard practice to key such riprap about one half meter into a "toe trench" that is dug into the streambed, approval not to make such a trench was obtained from the Broadwater Conservation District, which administers stream alteration permits, and from its advisers in the USDA Soil Conservation Service. Instead, the large foundation rocks were laid directly on the stream bed because the bed was already well armored with large stones. The resulting, unkeyed structure was more likely to have overhanging rock elements that would provide cover for trout.

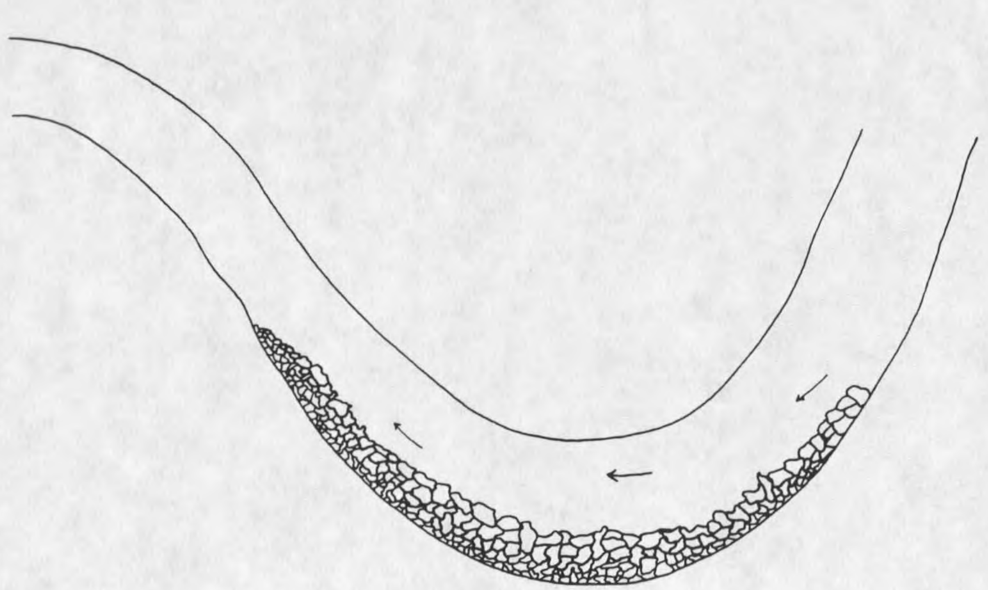

Figure 3. Typical Deep Creek bend after installation of riprap.