The Effects of Large Storm Events on Basin-Range Riparian Stream Habitats[1]

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Abstract.--Large storm events had major impacts on stream riparian reaches that had received heavy livestock grazing. One ungrazed rehabilitated stream reach actually improved in habitat condition while the two adjacent grazed stream reaches decreased. Each stream reacted differently to channel erosion, with two streams showing mainly lateral channel movement and the third stream vertical channel movement.

INTRODUCTION

This report describes habitat changes in three riparian stream systems from 1978 through 1984. This is a valuable period for analyzing environmental fluctuations because broad areas of the Great Basin experienced some of the lowest and highest stream flows on record.

STUDY AREA

The study streams are in Nevada (Chimney and Gance Creeks) on the northern fringe of the Basin and Range physographic province and in Utah (Big Creek) on the fringe of the middle Rocky Mountain physographic province (fig. 1). Historically the watersheds of all three streams have been heavily grazed by livestock. Complete descriptions of study streams can be found in Platts and others (1983b), Platts and Nelson (1983), and Platts and Nelson[3].

Few flow data exist for Chimney Creek. However, based on a nearby stream record, peak flows in 1984 were in the range of a 500-year flow event (Siebert personal communication). U.S. Geological Survey Records[4] collected on Gance Creek show peak flows of 114 cfs on May 30, 1983, and 127 cfs on May 12, 1984. These flows are approximately 2 to 14 times larger than mean annual discharge peak flows for 1980, 1981, and 1982, which were 60, 9, and 50 cfs, respectively. Flows for Big Creek are not available, but on June 4, 1983, the Bear River that Big Creek empties into, exceeded all past 40-year flow records (Millard and others 1983) at 3630 cfs and was nearly as high in 1984 at 3050 cfs (Harenburg personal communication).

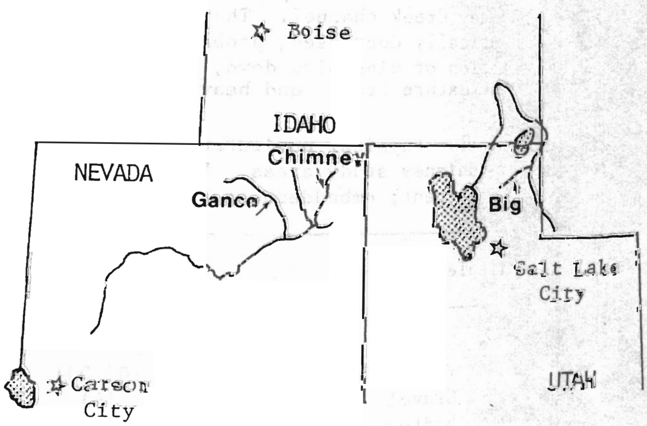

Figure 1.--Study site locations.

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[1] Paper presented at the North American Riparian Conference, Tucson, Arizona, April 16-18, 1985.

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[3] Platts, W. S., and R. L. Nelson. In press. Stream habitat and fisheries response to livestock grazing and instream improvement structures: Big Creek, Utah. Journal of Soil and Water Conservation.

[4] U.S. Geological Survey. 1984. Unpublished water level records. U.S. Geological Survey. Carson City, Nevada.

METHODS

The basic study design was to randomly select 1,800 ft of stream and subdivide it into 181 transects placed at 10-ft intervals along the stream for location of all data collection. A complete description of the geomorphic, riparian, hydrologic, and fish population methods can be found in Platts and others (1983a), Platts and others (in preparation), and Ray and Megahan (1979).

RESULTS

Chimney Creek

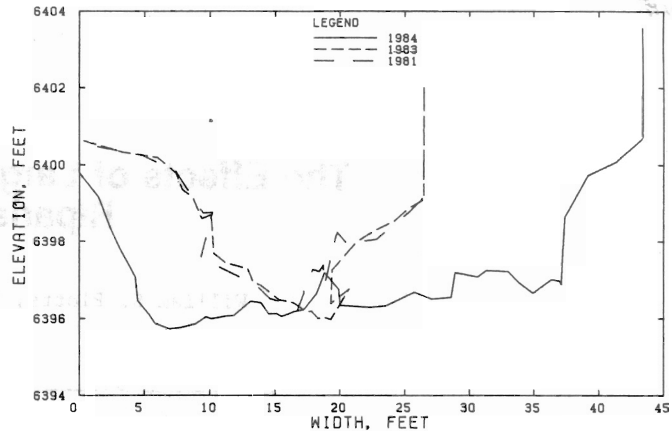
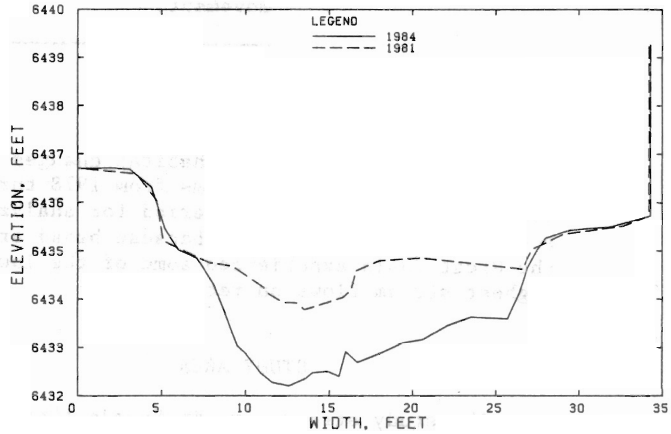


Figure 2.--Chimney Creek channel cross section 31, 1981-84.

Figure 3.--Chimney Creek channel cross section 146, 1981-84.



Chimney Creek suffered severe floods in 1983 and 1984 that unraveled the streambanks and made many channel changes (figs. 2 and 3). Table 1 shows the reduction of vegetative overhang in 1984, the year of most severe flooding. In 1981 there was little vegetative overhang, but this was during periods of heavy grazing. In 1982 and 1983, vegetative overhang increased because of two successive years without grazing. Grazing was also minimal in 1984, but the heavy bank scouring still reduced the overhang. The flooding increased fine sediments in the channel, but the scouring flushed gravel downstream and replaced it with rubble. The fines probably re-deposited as flood flows receded. The increased substrate embeddedness rating (1 is high, 5 is low) in 1984 reflected the increase of fine sediments. Chimney Creek became wider and deeper (table 1) after the floods of 1983 and 1984, but pool quality and pool-riffle ratio were reduced.

In years past, the Chimney Creek streamside zone was heavily dominated by large aspen trees. Evidence of this aspen forest still exists in the large amount of decomposing aspen logs in the Chimney Creek channel. The aspen population drastically decreased, probably because of a combination of wind blow down, beaver cutting the large mature trees, and heavy cattle grazing controlling the annual aspen sprouting and seedlings. The large aspen limbs and logs that held the Chimney Creek channel together decreased in volume and decomposed so that they no longer had the capacity to hold the acquired

Table 1.--Physical environmental means (plus or minus 95% confidence about the mean) for the Gance and Chimney study areas. Vegetative overhang, width, and depth in feet; fine sediments and gravel in percent; embeddedness and pool quality in units; and pool-riffle in ratio.

Variable	1978	1979	1980	1981	1982	1983	1984
Gance							
Vegetation overhang	0.10(.03)	0.13(.04)	0.12(.04)	0.11(.03)	0.30(.06)	0.15(.05)	0.06(.03)
Gravel	81 (4)	70 (3)	71 (4)	76 (3.8)	73 (3.6)	64 (3.6)	58 (4)
Width	5.2 (.3)	5.5 (.2)	6.3 (.3)	6.1 (.3)	6.0 (.3)	6.5 (.3)	7.4 (.3)
Chimney							
Vegetation overhang				0.06(.03)	0.16(.04)	0.11(.05)	0.05(.03)
Fine sediments				8.4 (-)	8.5 (-)	6.7 (-)	17.6 (-)
Gravel				57 (3.5)	48 (4.1)	40 (3.9)	18 (2.5)
Embeddedness				3.2 (.1)	2.7 (.1)	3.1 (.1)	1.7 (.1)
Width				4.7 (.3)	4.6 (.3)	5.5 (.3)	6.9 (.4)
Depth				0.15(.01)	0.17(0.02)	0.19(.01)	0.22(.02)
Pool quality				2.8 (.2)	3.1 (.02)	2.4 (.7)	1.8 (.2)
Pool-riffle ratio				2.7 (-)	2.7 (-)	1.7 (-)	1.0 (-)

Table 2.--Some examples of minimum channel elevations in feet and translocation distances[1] in feet at four selected stream transects.

	Year						
	1978	1979	1980	1981	1982	1983	1984
Stream							
Chimney							
Elevation				18		4	35
Translocation				6394.7		6394.7	6386.8
Elevation				9		10	31
Translocation				6395.9		6395.7	6388.3
Gance							
Elevation	11.2		7.7	8.7	4.3		17.1
Translocation	6520.6		6521.2	6521.3	6521.3		6521.3
Elevation		14.5	13	12.5	10.3		9
Translocation		6505.7	6506.7	6506.2	6505.5		6504.4

[1] Translocations are distances from the benchmark stake to the point of minimum channel elevation.

Table 3.--Fish biomass estimates in oz/ft^2 ($x10^{-2}$) for Chimney, Gance, and Big Creeks.

Study Area	1978	1979	1980	1981	1982	1983	1984
Chimney Creek, Nevada - Cutthroat trout							
	-	-	-	0.4	0.6	1.1	0.8
Gance Creek, Nevada - Cutthroat trout							
	1.1	1.6	3.2	2.3	1.2	1.1	1.4
Big Creek, Utah - Rainbow trout							
Site 1	-	0.3	0.7	-	-	-	0.2
Site 2	-	0.4	0.3	-	-	-	0.1
Site 3	-	0.5	0.1	-	-	-	0.2

alluvium underlying the channel. Consequently, large floods were capable of scouring valley alluvium materials and causing accelerated erosion of the Chimney Creek streambanks and channel (table 2).

The Humboldt cutthroat trout (*Salmo clarki henshawi*) not only survived the floods, but actually had higher summer populations during the high water years of 1983 and 1984 than during the lower water years of 1981 and 1982 (table 3). Drought conditions, which caused Chimney Creek to flow ephemerally, may cause more severe limiting factors than floods. Now that the Chimney Creek channel is largely modified, it will be interesting to see how cutthroat trout summer in Chimney Creek during the next drought years.

Gance Creek

Gance Creek mainly showed vertical change resulting from the major flood events (table 2 and fig. 4). But some cross section profiles (fig. 5 and 6) showed some lateral change. Because of its large vegetative canopy cover and streambank vegetation biomass dominated by trees, the Gance Creek streambanks were more resistant to lateral movement. Had Gance Creek sustained its past control by beaver dams that occurred in the 1950's and 1960's, it would probably have suffered even less from the high flows. The only variables possibly affected by the high flows would have been reduced gravel in the channel (similar to what happened in Chimney Creek), increased stream width primarily because of the higher summer flows, and reduced vegetative overhang.

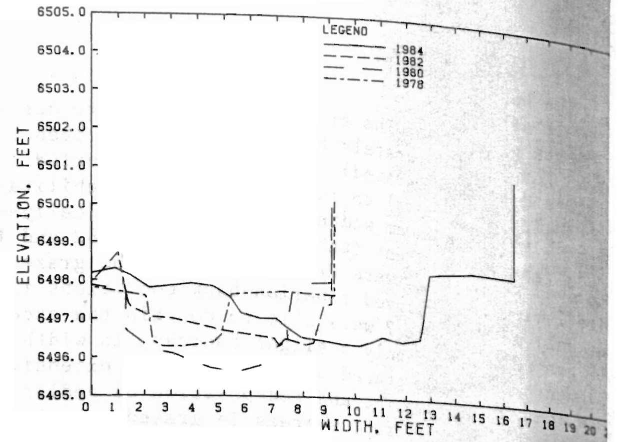
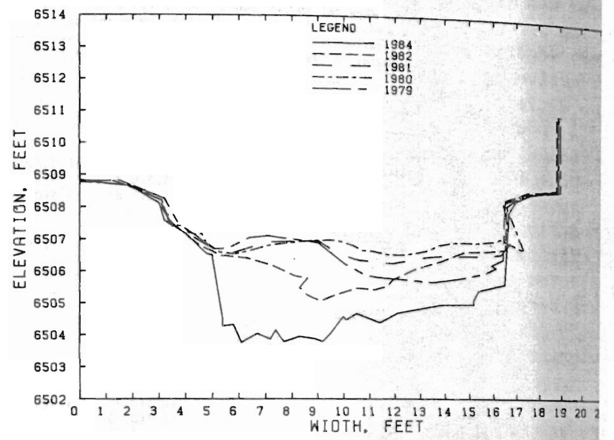


Figure 4.--Gance Creek channel cross section 43, 1978-84.

Figure 5.--Gance Creek channel cross section 89, 1979-84.



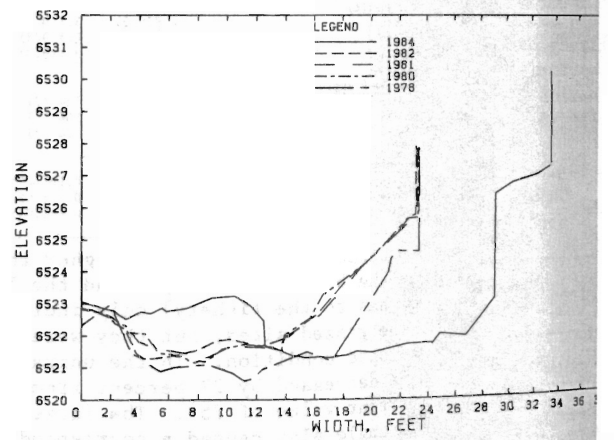


Figure 6.--Gance Creek channel cross section 147, 1978-84.

In Gance Creek the Humboldt cutthroat did best during the drier years of 1980 and 1981. However, the population during the flood years of 1983 and 1984 was quite similar to the lower flow years of 1978 and 1979. Gance Creek has better summer flows than Chimney Creek. Therefore, high flows could have more proportional effect on fish populations.

Big Creek

The sites on Big Creek are described separately because site 2 has been rested (ungrazed) for a sufficient period (about 10 years) to induce dramatic rehabilitative changes. Stream width increased dramatically--by about 40 percent (table 4)--between 1982 and 1984 (1983 and 1984 were flood years) in the grazed reaches. The improved riparian-bank conditions in the ungrazed site 2 were able to contain the excess streamflow, and only a slight increase in width occurred. In the grazed upstream site 3, extensive lateral movement and redeposition of bedload sediments occurred, whereas in grazed site 1, immediately downstream from the ungrazed site 2, there was extensive bank side cutting but reduced deposition of sediments occurred. This combination may have occurred because large volumes of fine sediments were trapped in the rehabilitated riparian zone of the adjacent upstream ungrazed site.

Table 4.--Physical environmental means (plus or minus confidence interval around the mean) for Big Creek. Habitat type and pool quality in units, bank alteration and fine sediments in percent, stream width and streambank undercut in feet, and streambank angle in degrees.

Variable	1978	1979	1980	1982	1984
Habitat type					
Site 1		12.9(0.8)	10.0(0.8)	14.2(0.6)	6.1( )
Site 2		15.3(0.8)	15.3(0.9)	16.5(0.6)	16.2( )
Site 3		11.8(0.8)	13.5(0.8)	14.7(0.6)	8.8( )
Bank alteration					
Site 1		42(-)	69(-)	59(-)	64(-)
Site 2		16(-)	27(-)	25(-)	23(-)
Site 3		34(-)	63(-)	55(-)	64(-)
Fine sediments					
Site 1	15.5()	10.3(-)		21.2(-)	
Site 2	49.9(-)	45.1(-)		39.8(-)	
Site 3	48.1(-)	31.1(-)		34.4(-)	
Width					
Site 1		12.5(0.7)	13.3(0.8)	12.5(0.8)	17.9(1.0)
Site 2		11.7(0.7)	12.3(0.8)	11.7(0.8)	14.0(0.9)
Site 3		12.9(0.7)	13.8(0.8)	13.1(0.8)	18.2(1.8)
Pool quality					
Site 1		2.8(0.3)	3.1(0.3)	3.2(0.3)	3.2(0.3)
Site 2		3.6(0.3)	4.5(0.3)	4.1(0.3)	3.7(0.3)
Site 3		3.1(0.3)	3.9(0.3)	3.6(0.3)	3.2(0.4)
Streambank angle					
Site 1		136 (8)	134 (7)	121 (7)	123 (8)
Site 2		113 (8)	104 (7)	103 (7)	75 (8)
Site 3		138 (8)	124 (8)	125 (7)	125 (8)
Streambank undercut					
Site 1		0.08(.05)	0.10(.05)	0.19(.06)	0.19(.06)
Site 2		0.20(.05)	0.22(.05)	0.29(.06)	0.50(.09)
Site 3		0.07(.05)	0.14(.05)	0.18(.06)	0.23(.06)

Streambank angle (the higher the angle the more the bank is outsloped and the less value the bank has to the fishery) only increased slightly in the grazed sites, but they were already in an outsloped condition. In the ungrazed site, bank angle decreased by 27 percent from 1982 to 1984 to a current value of 75°. The large decrease in bank angle also caused a corresponding 72 percent increase in bank undercut, a move toward better salmonid conditions.

The habitat type (a vegetative classification by form) rating decreased dramatically in the grazed sites because of the large increase in newly eroded sediments dominating the streambank structure and the increase in exposed banks created by lateral movement and bank scour. Streambank alteration was much higher after the floods (1983-84) in the grazed sections but did not change much in the ungrazed section, reiterating the ability of the improved stream-riparian condition in the ungrazed area to resist damage from unusual runoff events.

Heavy recreational fishing pressure effectively reduced trout numbers in site 2 (the livestock exclosure) because of better pool quality. This heavier fishing pressure makes it difficult to evaluate influences on fish populations from recent flooding. It is clear, however, that improved riparian-streambank condition in the ungrazed area has not benefitted the fish population. We believe this is because the large number of instream improvement structures trapped fine sediments, and offsite limiting factors (high water temperatures) from upstream grazed reaches cancel any of the benefits gained (Platts and Nelson[3/]).

CONCLUSIONS

Historically, researchers and managers have been interested in the effects from large flood events (Lyons and Beschta 1983; Gregory and Madew 1982). The runoff years of 1983 and 1984 were intensive, resulting in marginal to dramatic changes in riparian stream habitat of the three study streams. Where streamside vegetation was abundant, flood impacts were minimal.

Major mechanisms leading to changes in channel morphology and thus changes in fishery and riparian habitat, are the resistance of material to fluvial entrainment and the physical destruction of streambanks. These two mechanisms can be controlled, to some extent, by the types of land use and management in the riparian stream zone. If streambank vegetation is reduced, the stream usually responds by an adjustment of channel width. Physical destruction of the streambank results in delivery of sediments to the channel. The initial response of channels to these increased sediments is to reduce bedform roughness (Heede 1980; Jackson and Beschta 1984). In most cases this is accomplished by filling pools with sediments. Subsequent adjustments may include changes in width, depth, meander pattern or longitudinal profile. When these adjustments take place, riparian stream habitats suffer, and fish populations usually suffer.

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