EFFECTS OF THE 1995/96 FLOODS ON STREAMS IN NORTH CENTRAL IDAHO

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ABSTRACT: Sixteen channel and habitat parameters on 13 stream reaches in north-central Idaho were measured before and after the 1995/96 floods, which were of 25 to 100-year magnitudes. Sixteen of the 172 total comparisons possible were significant at the 10% level, and five were significant at the 5% level. Global averages of the 16 measured parameters over all study reaches showed six that were significant at the 10% level, and three that were significant at the 5% level. The only trend that could be inferred was a general decrease in width-to-depth ratios, but changes were not consistent from stream to stream. The results indicate that either the streams did not change significantly as a result of the event, or the sampling methodology used was inadequate to evaluate channel changes over time.

KEY TERMS: forest hydrology, flood effects, channel morphology.

INTRODUCTION

High streamflows during extreme floods can affect channel stability, fish habitat, and riparian vegetation (Olsen et al, 1997; Falter and Rabe, 1997; Lisle, 1981). In addition, extreme precipitation events may trigger increases in landslide activity, which can impact sediment loads in streams (Falter and Rabe, 1997), further affecting fish habitat conditions, particularly as they relate to salmonid embryo survival (Chapman, 1988).

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Several studies examining channel response to floods have focussed on recovery of large rivers over a relatively long period of time. Burkham (1972) found that the Gila River in Arizona widened substantially due to severe flooding during the period 1905-17, but subsequent deposition during the period 1918-70 reconstructed the floodplain and allowed the stream banks to revegetate, resulting in an active channel width near what it was prior to 1905. Lisle (1981) reported that channel widening was a widespread result of flooding in northern California, particularly in 1964, but that in humid climates channels often narrow and banks revegetate within a few years, whereas in arid climates it may take decades for channels and banks to recover. Lyons and Beschta (1983) reported a significant increase in channel width of the Middle Fork Willamette River in Oregon between 1959 and 1967, presumably due to the 1964 flood, and a trend toward narrowing channels again by 1979. Nolan and Marron (1995) attribute channel widening of Redwood Creek in northern California to floods in 1964 and 1972, with a trend of channel narrowing and deepening during the period 1975-82. All of these studies relied primarily on aerial photography interpretation and/or stream cross-sections at USGS stream gauge locations for their analyses. Rivers in these studies had average widths exceeding 100 feet and gradients less than 1%.

Channel widening, scour, increased channel migration, and channel destabilization in urban areas have been attributed to increased peak flows due to increases in impervious area resulting from housing, paving, and construction activities (Booth, 1991; Leopold, 1973). However, few studies have utilized monumented cross-sections located throughout a stream reach in a forested watershed to assess impacts of severe flooding on channel morphology; Falter and Rabe (1997) and Pipp et al (1997), both of examined streams in the Clearwater River drainage in north-central Idaho before and after the floods of winter/spring 1995/96.

Two different major flood events occurred in north-central Idaho during the winter of 1995-96. In November of 1995, a rain-on-snow event resulted in streamflows approximating a 25-year recurrence frequency (USGS unpublished data). In early February 1996, a large storm inundated the Pacific Northwest; in northern Idaho, rain-on-snow resulted in streamflows that approached or exceeded the 100-year flood peak (Beckwith et al, 1996).

Pipp et al (1997) compared a number of channel and habitat parameters before and after the flood; the only consistent change was a decrease in acting large woody debris (LWD), although cobble embeddedness and channel cross-sectional area both increased more often than they decreased. Similarly, Falter and Rabe (1997) did statistical comparisons of 20 channel variables over 15 stream reaches before and after the flood and found statistically significant changes in 67 of the 300 cases, but the changes were inconsistent - a given parameter may have increased in one stream reach, but decreased in another.

The study described herein compares 16 channel and habitat parameters measured before and after the 1995/96 floods on 13 stream reaches located throughout north-central Idaho. The analysis provides an opportunity to examine both channel changes due to floods, and to evaluate the Beneficial Use Reconnaissance Project (BURP) (IDEQ, 1995) sampling protocol. Our null hypothesis was that the measured parameters after the flood would not be significantly different from those measured prior to the flood.

METHODS

Field Sampling

Stream surveys were conducted in June and July of 1995, and again in June and July of 1996. A two-person survey team sampled all 13 streams in 1995. The two-person team conducting the 1996 surveys included one person from the 1995 team and one new person. Data collection procedures followed the BURP protocol established by the Idaho Division of Environmental Quality (IDEQ, 1995).

Figure 1 shows the location of each of the 13 study reaches. Table 1 summarizes the general characteristics of each of the 13 streams sampled in this study. These reaches were located at the lower ends of watersheds, on Potlatch Corporation ownership, attempting to use "response type" reaches as defined by Montgomery and Buffington (1993). Accessibility was also a consideration.

Upon arrival at the stream site, the observers first verified that the selected site was representative of the general conditions of the selected stream reach. Observers then chose a convenient starting point. The observers then walked upstream, along the banks when possible, reviewing the general characteristics of the reach. An estimate was made of the (average) wetted channel width of the stream. The gradient of the reach was measured with a clinometer. Rebar stakes were deposited at locations of pool and riffle cross-sections. When there was a shortage of adequate pools or riffles, runs or glides were used for cross-sections. A total of six cross-sections were completed at each stream site in 1995. Once the observers reached a distance that they measured as the greater of 20 times the wetted channel width or 100 meters, they established an upstream endpoint of the reach where flagging and rebar stakes were placed.

The beginning of the reach was monumented with rebar stakes on both sides of the stream and photographs taken. A metal tag with the stream site number was attached to one of the rebar. Flagging also marked the beginning of the reach.

The observers moved upstream to the channel cross-section locations where rebar stakes had been previously deposited. The rebar stakes were driven into the ground above normal bankfull water levels. A tape was tightly strung between the stakes across the stream as level as possible.

Using a stadia rod, the height from the streambed to the tape was recorded for a minimum of 10 points along the cross-section, as well as the bankfull and wetted edge on each side of the stream. The cross-section rebar stakes were painted, and an identifier tag was attached to one stake. The stakes were flagged and a compass bearing from one stake to the other stake was recorded. Some cross-section stakes were removed by the 1996 flood; when less than four of the previous six cross-sections from 1995 were left intact in 1996, replacement cross-sections were created. Four canopy density measurements were taken at each of the six cross-sections using a densiometer: facing each bank one foot from the wetted edge, and at the middle of the stream facing upstream and facing downstream.

Pool cross-sections were not always taken at the deepest part of the pool. The pool cross-sections were located such that the observers could measure safely and accurately. In larger streams, this often resulted in location of the pool cross-section closer to the pool tail-out than would have been desirable.

Approximately two feet downstream from each riffle cross-section, Wolman pebble counts of fifty particles each were measured. These transects ran from the scoured bottom of one stream edge to the scoured bottom of the other side of the stream. Intermediate diameters were recorded for each of 50 particles.

Additional data were recorded at pools in an attempt to describe pool quality. Pool tail-out depth, maximum depth, average depth, an estimate of the average particle size, percent of the pool affected by overhanging vegetation and debris, percent of the pool that provided instream cover for fish, and percent of the bank with existing undercut banks were recorded.

The locations of each cross-section and Wolman pebble count were recorded. A count of the number of pieces of LWD at least three feet long and four inches in diameter within bankfull level was recorded.

Using aerial photos and detailed topographic maps, the observers ascertained the precise location of the start of the study reach, which was later entered into a GIS database.

Analysis

The following 16 parameters were used in the data analysis:

Average wetted width - all cross-sections: the wetted width was calculated for each of the four to six cross-sections available.

Average wetted depth - all cross-sections: the highest wetted edge was equated to zero depth, and all points below that level were averaged to generate an average wetted depth for each of the four to six cross-sections available.

Width-to-depth ratio - all cross-sections: the width-to-depth ratio was calculated for each cross-section by dividing the wetted width by the average wetted depth for each of the four to six cross-sections available.

Number of LWD: a count of the number of pieces of wood at least three feet long and four inches in diameter within the reach.

Fines ≤2mm: three riffles were sampled within each stream reach, and 50 pebbles were measured at each riffle. A value of percent fines less than or equal to 2 mm was calculated for each riffle.

Fines <6.4mm: three riffles were sampled within each stream reach, and 50 pebbles were measured at each riffle. A value of percent fines less than or equal to 6.4 mm was calculated for each riffle.

Pool average residual depth - all pools: during the habitat surveys, the maximum pool depth and tail-out depth were measured for all pools within the reach. Subtracting the tail-out depth from the maximum depth generated the pool residual depth for each pool. The sample size for the number of pools in a reach varied from one to 12.

Pool average wetted width: the wetted width was calculated for each of the one to three pool cross-sections available.

Pool average wetted depth - cross-sections: the highest wetted edge for each pool cross-section was equated to zero depth, and all points below that level were averaged to generate an average wetted depth for each of the one to three cross-sections available.

Pool average wetted depth - all pools: during the habitat surveys, a number of pool depth sample points were measured to derive an observer estimate of the average depth for each pool within the reach. The sample size for the number of pools varied from one to 12.

Pool width-to-depth ratio: the width-to-depth ratio was calculated for each pool cross-section by dividing the wetted width by the average wetted depth for each of the one to three pool cross-sections available.

Riffle average wetted width: the wetted width was calculated for each of the one to four riffle cross-sections available.

Riffle average wetted depth: the highest wetted edge for each riffle cross-section was equated to zero depth, and all points below that level were averaged to generate an average wetted depth for each of the one to four riffle cross-sections available.

Riffle width-to-depth ratio: the width-to-depth ratio was calculated for each riffle cross-section by dividing the wetted width by the average wetted depth for each of the one to four riffle cross-sections available.

Pebble d84: three riffles were sampled within each reach, and 50 pebbles were measured at each riffle. A d84 value was calculated for each riffle.

Pebble d50: three riffles were sampled within each reach, and 50 pebbles were measured at each riffle. A d50 value was calculated for each riffle.

For each parameter and each study reach, a paired t-test was performed to determine whether the change in the reach average value of the parameter between 1995 and 1996 showed a significant difference (either positive or negative). One exception was number of LWD, as there was only one number for each reach in each year and no associated variance, a t-test could not be performed. P-values less than 0.05 were considered significant, but P-values less than 0.10 were also considered noteworthy.

RESULTS AND DISCUSSION

Table 2 shows the sample sizes and associated P-values for each t-test comparison. Table 3 shows the average value of each parameter for 1995 and 1996 for each stream reach. For the 172 total comparisons possible among individual stream reaches, five were significant at the 5% level; an additional 11 were significant at the 10% level. Of the 16 comparisons that indicated significant changes at the 10% level, average riffle depth was the only parameter that showed a significant and consistent change in more than one stream reach; the riffle depth was greater in 1996 than it was in 1995 in both Lower Site Middle Fork St. Maries and Indian Creek. Other parameters showed significant changes in more than one reach, but the direction of change was inconsistent. Pool residual depth, particle d84, and particle d50 showed significant but inconsistent changes in Ruby Creek and Alder Creek; Potlatch River and Hugus Creek; and Potlatch River and Hugus Creek, respectively.

Parameters showing significant changes at the 5% level in one stream reach only included: pool depth for all pools (decreased in Ruby Creek), fines <6.4mm (increased in Upper Site Washington Creek), particle d84 (decreased in Hugus Creek), and particle d50 (decreased in Hugus Creek and increased in Potlatch River).

Table 3 also shows the average value of each parameter calculated over all study reaches. Of the 16 parameters measured in this study, differences in the global averages were significant at the 5% level in three cases, and significantly different at the 10% level in three additional cases. Only five of these parameters are actually independent: average pool depth at cross-sections decreased; average pool depth of all pools increased; pool residual depth increased; riffle width-to-depth ratio decreased; and reach average width-to-depth ratio decreased (related to decrease in reach average width). Of these five differences in global averages (at the 10% level of significance), four can be categorized as being beneficial to fish habitat, only the decrease in pool depth at cross-sections would be categorized as detrimental to fish habitat. The general trend of these changes appears to be toward decreased width-to-depth ratios, possibly due to increased stream depth and/or decreased stream width.

Although some of the global averages indicate significant changes, many of the changes were inconsistent - a given parameter may have increased in one stream reach, but decreased in another - which is similar to the results of Pipp et al (1997) and Falter and Rabe (1997). The d84 and d50 measures are a good example of this result - d84 and d50 increased significantly in the Potlatch River, but decreased in Hugus Creek. Furthermore, although the global averages indicate some stream parameters may have changed significantly on a large scale across the entire study area, significant changes within individual stream reaches were rare.

There are two possible conclusions to draw from these results. First is that the flood effects in these channels were small or nonexistent. The number of statistically significant differences is entirely consistent with expectations on making a large number of tests. For example, 172 tests at the 10% significance level will on average identify 17 significant differences for random samples from two identical populations; likewise for a 5% significance level, nine significant differences will be identified (Snedecor and Cochran, 1976). These numbers compare well to the 16 and five significant differences identified at the 10% and 5% levels, respectively, in this study. The second possible conclusion is that the sample sizes were insufficient to detect real differences within individual stream reaches. Most of the sample sizes in this study were six or less (Table 2). If this is true, then the sampling protocol currently being used by the state of Idaho (IDEQ, 1995) is insufficient to monitor changes in stream condition over time. If it cannot detect changes resulting from a large flood, it seems unlikely that it could detect more subtle changes associated with land use.

CONCLUSIONS

This study examined 16 channel and habitat parameters measured before and after the 1995/96 floods on 13 stream reaches located throughout north-central Idaho. Of the 172 total comparisons possible, 16 were significant at the 10% level, and only five were significant at the 5% level. Global averages of the 16 measured parameters over all study reaches showed six that were significant at the 10% level, and only three that were significant at the 5% level. The only trend that could be inferred was a general decrease in width-to-depth ratios, which would generally be considered beneficial to fish habitat, but changes were not consistent from stream to stream. The results may also indicate that this sampling methodology is inadequate to evaluate channel changes over time, if they occur.

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Table 1. Study Reach Characteristics

	Ruby Creek	Potlatch River	Upper Site Mid. Fk. St. Maries River	Lower Site Washington Creek	Lower Site Mid. Fk. St.Maries River	Upper Site Washington Creek	Lower Site Boulder Creek	Reeds Creek	Hugus Creek	Indian Creek	Camas Creek	Alder Creek	Upper Site Boulder Creek
Reach length (feet)	330	600	725	700	1,000	330	700	425	529	330	330	530	345
Average gradient	3.0%	1.0%	3.0%	4.0%	3.0%	2.0%	5.0%	2.5%	2.0%	3.0%	2.0%	2.0%	1.5%
Rosgen channel type	E4	C3	C3	B3	C3	E4	A1, B3	C3	C3	C4	E5	A2, E5	C5
Predominant geology	Gneiss	Basalt	Gneiss	Granitic	Schist	Granitic	Gneiss	Schist	Schist	Siltite	Siltite	Granitic	Basalt

Table 2. Sample sizes and P-values from paired t-test comparisons

Parameter		Ruby Creek	Potlatch River	Upper Site Mid. Fk. St. Maries River	Lower Site Washington Creek	Lower Site Mid. Fk. St.Maries River	Upper Site Washington Creek	Lower Site Boulder Creek	Reeds Creek	Hugus Creek	Indian Creek	Camas Creek	Alder Creek	Upper Site Boulder Creek	All Reaches
Average Wetted Width - all x-sections (feet)	samples	5	6	6	4	5	6	6	6	0	6	6	2	4	62
	P-value	0.51	0.09	0.74	0.72	0.29	0.90	0.19	0.74	N/A	0.14	0.49	0.46	0.67	0.07
Average Wetted Depth - all x-sections (feet)	samples	5	6	6	4	5	6	6	6	0	6	6	2	4	62
	P-value	0.84	0.18	0.11	0.29	0.38	0.57	0.50	0.09	N/A	0.86	0.98	0.36	0.30	0.77
Width to Depth Ratio - all x-sections	samples	5	6	6	4	5	6	6	6	0	6	6	2	4	62
	P-value	0.25	0.68	0.12	0.51	0.22	0.98	0.48	0.11	N/A	0.38	0.75	0.28	0.18	0.06
Number of LWD	samples	0	0	1	1	1	1	1	1	1	1	1	1	1	11
	P-value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.82
Fines < 2mm (percent)	samples	3	3	3	3	3	3	3	3	2	3	3	2	3	37
	P-value	0.34	1.00	0.63	0.67	0.42	0.13	0.42	0.57	0.50	0.07	0.84	0.50	0.26	0.18
Fines < 6.4 mm (percent)	samples	3	3	3	3	3	3	3	3	2	3	3	2	3	37
	P-value	0.33	0.42	0.37	0.23	0.62	0.04	0.37	0.65	0.98	0.76	0.93	0.24	0.35	0.32
Pool Average Residual Depth - all pools (feet)	samples	3	1	1	3	3	5	9	3	2	6	6	2	4	48
	P-value	0.07	N/A	N/A	0.27	0.67	0.62	0.32	0.70	0.32	0.34	0.25	0.08	0.18	0.01
Pool Average Wetted Width (feet)	samples	2	3	1	2	2	3	3	3	0	3	3	1	2	28
	P-value	0.50	0.09	N/A	0.49	0.24	0.74	0.53	0.47	N/A	0.28	0.85	N/A	0.15	0.40
Pool Average Wetted Depth - x-sections (feet)	samples	2	3	1	2	2	3	3	3	0	3	3	1	2	28
	P-value	0.38	0.21	N/A	0.53	0.08	0.63	0.65	0.15	N/A	0.58	0.37	N/A	0.91	0.02
Pool Average Wetted Depth - all pools (feet)	samples	3	1	1	3	3	5	9	3	2	6	6	1	4	47
	P-value	0.01	N/A	N/A	0.63	0.18	1.00	0.61	0.20	0.50	0.20	0.33	N/A	0.32	0.07
Pool Average Width to Depth Ratio	samples	2	3	1	2	2	3	3	3	0	3	3	1	2	28
	P-value	0.11	0.19	N/A	0.51	0.33	0.57	0.37	0.17	N/A	0.22	0.41	N/A	0.11	0.14
Riffle Average Wetted Width (feet)	samples	3	3	4	2	3	2	3	3	0	3	3	1	2	32
	P-value	0.70	0.10	0.50	0.45	0.24	0.63	0.32	0.43	N/A	0.52	0.30	N/A	0.50	0.11
Riffle Average Wetted Depth (feet)	samples	3	3	4	2	3	2	3	3	0	3	3	1	2	32
	P-value	0.49	0.75	0.17	0.67	0.06	0.53	0.53	0.40	N/A	0.08	0.30	N/A	0.30	0.12
Riffle Average Width to Depth Ratio	samples	3	3	4	2	3	2	3	3	0	3	3	1	2	32
	P-value	0.24	0.85	0.17	0.88	0.21	0.86	0.83	0.53	N/A	0.28	0.24	N/A	0.72	0.02
Pebble d84 (mm)	samples	3	3	3	3	3	3	3	3	2	3	3	2	3	37
	P-value	0.11	0.08	0.98	0.14	0.18	0.24	0.77	0.38	0.04	0.37	0.21	0.64	0.29	0.57
Pebble d50 (mm)	samples	3	3	3	3	3	3	3	3	2	3	3	2	3	37
	P-value	0.26	0.05	0.48	0.79	0.30	0.85	0.80	0.15	0.04	0.64	0.65	0.50	0.40	0.85

Underlined entries indicate significant difference at 5% level.

N/A - insufficient sample size to perform t-test.

Shaded entries indicate significant difference at 10% level.

Table 3. Average values of measured parameters

Parameter	Year	Ruby Creek	Potlatch River	Upper Site Mid. Fk. St. Maries River	Lower Site Washington Creek	Lower Site Mid. Fk. St.Maries River	Upper Site Washington Creek	Lower Site Boulder Creek	Reeds Creek	Hugus Creek	Indian Creek	Camas Creek	Alder Creek	Upper Site Boulder Creek	All Reaches
Average Wetted Width - all x-sections (feet)	1995	11.3	26.9	20.5	33.1	34.0	18.0	13.5	19.1	14.0	7.3	4.6	20.6	5.9	17.4
	1996	9.9	24.5	20.4	32.5	27.0	18.0	11.9	19.3	17.3	8.3	5.3	18.7	5.3	16.4
Average Wetted Depth - all x-sections (feet)	1995	0.5	0.7	0.5	0.7	0.7	0.7	0.4	0.7	0.7	0.3	0.2	0.8	0.2	0.50
	1996	0.5	0.6	0.6	0.8	0.9	0.6	0.3	0.5	0.6	0.3	0.2	0.7	0.2	0.49
Width to Depth Ratio - all x-sections	1995	47	57	52	53	81	36	49	34	29	49	28	26	37	47
	1996	25	61	34	48	36	36	57	43	22	36	26	28	28	39
Number of LWD	1995	15	8	10	62	7	42	21	6	12	28	64	101	15	33
	1996	---	---	11	68	4	38	29	4	55	28	60	65	20	35
Fines < 2mm (percent)	1995	8	5	7	3	5	20	5	16	2	7	27	39	55	15
	1996	13	5	8	2	7	29	7	11	0	10	30	29	78	18
Fines < 6.4 mm (percent)	1995	10	11	8	6	10	24	10	19	6	11	37	50	65	20
	1996	19	10	11	4	8	34	7	15	6	13	39	40	85	22
Pool Average Residual Depth - all pools (feet)	1995	1.0	2.5	0.7	1.6	2.0	1.1	1.5	1.2	1.8	0.7	0.7	1.7	0.5	1.2
	1996	0.8	1.9	1.7	2.0	2.1	1.1	1.7	1.1	2.3	0.6	0.9	2.9	0.6	1.4
Pool Average Wetted Width (feet)	1995	12.5	27.4	26.1	35.7	23.5	18.6	16.4	18.7	15.0	7.1	4.4	23.3	8.6	17.4
	1996	11.3	27.0	23.7	33.0	25.7	18.6	14.9	19.8	23.2	8.5	4.8	19.8	6.3	17.0
Pool Average Wetted Depth - x-sections (feet)	1995	0.9	1.0	0.6	0.9	1.3	0.7	0.6	1.0	1.0	0.4	0.3	0.9	0.2	0.71
	1996	0.6	0.9	0.7	1.0	1.1	0.8	0.5	0.7	0.9	0.3	0.2	0.6	0.2	0.62
Pool Average Wetted Depth - all pools (feet)	1995	0.8	1.7	1.0	1.9	1.5	1.1	1.2	1.1	1.5	0.5	0.5	2.2	0.4	1.02
	1996	0.7	2.0	1.3	2.0	1.8	1.1	1.3	1.0	1.6	0.6	0.6	2.5	0.5	1.09
Pool Average Width to Depth Ratio	1995	16	29	46	39	19	26	27	21	15	20	15	27	47	26
	1996	19	32	34	33	25	23	37	32	25	27	21	31	35	29
Riffle Average Wetted Width (feet)	1995	10.5	26.4	19.9	30.6	41.0	18.4	10.6	19.4	13.0	7.4	4.7	17.8	3.2	17.5
	1996	8.9	22.0	20.1	32.0	28.0	18.6	8.8	18.8	11.3	8.1	5.7	17.6	4.4	15.9
Riffle Average Wetted Depth (feet)	1995	0.2	0.3	0.4	0.5	0.4	0.7	0.2	0.4	0.3	0.1	0.1	0.7	0.1	0.32
	1996	0.3	0.3	0.6	0.5	0.7	0.3	0.1	0.4	0.6	0.2	0.2	0.7	0.2	0.38
Riffle Average Width to Depth Ratio	1995	68	86	58	67	122	56	71	47	44	79	41	24	27	66
	1996	29	89	33	64	44	61	77	53	18	44	31	26	21	49
Pebble d84 (mm)	1995	61	108	170	190	98	256	235	153	101	100	31	230	24	133
	1996	78	152	170	264	119	211	283	125	55	111	18	214	21	140
Pebble d50 (mm)	1995	36	62	78	86	61	35	84	72	55	41	12	67	11	53
	1996	28	79	63	88	68	33	80	52	29	48	9	121	1	53

Underlined entries indicate significant difference at 5% level.

Shaded entries indicate significant difference at 10% level.

Study Site Locations
1995 and 1996