Title
Waiting for rain: Baseline geomorphic analysis of the upper Carmel River watershed following the Basin Complex and Indians Fire of June - July, 2008

Author
Richmond, Sarah F

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Sarah Richmond
sarahrichmond@berkeley.edu
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Abstract

Wildfire in steep, chaparral watersheds increases runoff and erosion, which increases sediment transport from the hillslopes to the channel network. This process may cause a flux of fine sediment into streams, burying riffles and pools, or might cause a debris flow borne flux of large boulders and woody debris, eventually creating new complex fish habitat. The Basin Complex and Indians Fire of June – July, 2008 burned almost the entire upper Carmel River watershed (116 km^2) in the Los Padres National Forest, Monterey County, California. I made field observations of dry ravel in a steep, narrow tributary and conducted channel surveys and grain size analysis in riffles and pools at two study reaches along the mainstem upper Carmel River. This baseline geomorphic analysis will allow me to monitor the changes in threatened steelhead and resident trout (*Oncorhynchus mykiss*) spawning and rearing habitat this winter and compare these changes with those observed along the same study reaches following the Marble Cone Fire of August, 1977, which burned the same area with similar intensity. This comparison provides the opportunity to investigate the significance of winter rains and advance more process-based restoration of aquatic habitats affected by fire.

1. Introduction

Climate change is expected to increase the total annual area burned in California, ranging from 9 – 15% above the historical norm by the end of the century (*Lenihan et al*., 2008). Wildfire typically increases runoff and erosion, which transport fine sediment, large boulders, and woody debris from hillslopes to the stream channel network. This deposition can cover riffles and fill pools, or form new complex aquatic habitat (*Miller et al.,* 2003). Our limited understanding of the short and long-term effects of fires on fish habitat contributes considerable uncertainty to assessing the risk and benefits of different fire management alternatives to fish (*Dunham et al*., 2003). This study addresses this knowledge gap by focusing on the short-term geomorphic effects of fires on steelhead habitat.

The Basin Complex and Indians Fire combined and burned approximately 950 km^2 of mostly Los Padres National Forest land from June 8 – July 27, 2008. The burned area included the upper Carmel River watershed above Los Padres Dam, a municipal water supply source for the Monterey Peninsula

(Fig. 1). Burn severity varied in the watershed: 12 percent was high severity, 37 percent was moderate severity, 19 percent was low severity, and 32 percent was very low severity. High severity fire primarily impacted the upper hillslopes, and low and very low severity fire primarily impacted areas along the mainstem Carmel River (Fig. 2). Fire completely denuded some headwater tributaries of vegetation (*Holdeman and Pyron*, 2008).

Since Los Padres Dam blocks access to the upper Carmel River watershed, migrating steelhead are captured below the dam, transported above the dam by trucks, and released into Los Padres Reservoir. This effort allows adult steelhead to reach high quality spawning and rearing habitat in the tributaries and mainstem Carmel River. Steelhead spawn in relatively sediment-free gravels in riffles and pool tailouts, and the accumulation of sediment in spawning gravels reduces the flow of oxygen to redds. Steelhead rear in shallow crevices between cobbles and boulders in riffles until they grow large enough to reside in deeper pools. These crevices and pools provide temperature and flow refugia, and the accumulation of sediment reduces the quantity and quality of this rearing habitat.

1.1 Study Area

The upper Carmel River watershed drains 116 km^2 of the rugged, northern slopes of the Santa Lucia Mountains. Faulted crystalline rocks, primarily granodiorite and gabbro, weather to produce large amounts of medium-grained sand in the watershed (*Rosenberg*, 2001). Slopes commonly exceed 30° and average rainfall almost doubles from 610 mm (24 in.) at Los Padres Dam (elevation 317 m) to 1150 mm (45 in.) at the drainage divide with the Big Sur watershed to the west (elevation 1480 m). The variable topography and climate support chamise/chaparral on steep and exposed slopes, oak/madrone on more protected slopes and terraces, and mixed hardwood/coniferous forest at high elevations.

1.2 Fluvial Geomorphic Response to Wildfire

The "Flood Fire Sequence" describes two different geomorphic processes that increase the sediment load in burned watersheds (*Rice*, 1982). First, dry raveling occurs during or immediately after a fire, whereby soil, rock, and debris move downslope by gravity. The slope threshold for dry ravel is about 30° (*Rice*, 1982). The immediate effect of fire on dry ravel is to increase the rate of downslope movement because vegetation and the litter layer, which previously stabilized the weathered surficial debris, are removed by fire (Fig. 3). Dry ravel deposits accumulate on the lower parts of hillslopes and in stream channels until mobilized by storm flows (*Krammes*, 1965). Sediment delivered by dry ravel and small landslides may cause temporary aggradation in stream channels following fires, but it does not remain in fluvial systems for long periods of time (e.g., *Florsheim et al*., 1991).

Second, hydrophobic soils increase surface runoff and erosion during the first significant winter storms. Hydrophobic soils form during a fire when vaporized organic compounds condense in the soil subsurface and create a layer that impedes water infiltration (*Debano, 1981*). As a result, much of the rainfall that would have normally percolated into the soil becomes overland flow. Overland flow on hillslopes concentrates into rills, causing soil loss and additional sediment transported from the hillslopes to the channel network.

1.3 Upper Carmel River Following the Marble Cone Fire, 1977

Hecht (1981) monitored channel bed conditions for three years following the 1977 Marble Cone Fire. He recorded the net sequence of fill and scour at six cross-sections in three riffles and assessed the channel bed substrate with pebble counts. He found that riffles aggraded up to 0.3 m, primarily with sand, during first storms in December, 1977 and January, 1978. By the end of the first winter, 57 – 100 percent of the maximum net fill had been scoured, where primarily pebble and cobble size particles remained. Thus, the availability of spawning-sized material increased in most riffle cross-sections during the first year after the fire and probably decreased thereafter. *Hecht* (1981) also observed the floods following the fire removed much of the organic matter that had accumulated in the channel. Most fallen trunks and limbs on or spanning the bed were dislodged and then either washed through to Los Padres Reservoir or wedged in between the trunks of larger riparian trees along the banks. He concluded that minimal spawning and rearing habitat was available during the period of maximum fill, and increasing habitat availability as the sediment gradually scoured. By the end of the third year, channel geometry and grain size returned to within 20 percent of their pre-fire conditions (Fig. 4).

This study has three primary objectives related to an ongoing effort to monitor the channel response to the Basin Complex and Indians Fire after each significant storm this winter:

1. Establish baseline conditions: I performed post-fire, pre-rain field observations, channel surveys, and grain size analysis against which to measure future changes in spawning and rearing habitat at two sites on the upper Carmel River.
2. Learn from the 1977 Marble Cone Fire: My study replicates and expands upon the methods in *Hecht* (1981). I will compare my findings with *Hecht* (1981) since Marble Cone Fire burned a similar area at a similar intensity.
3. Restoration implications: This study explores the conditions for implementing natural recovery and Burned Area Emergency Rehabilitation (BAER) measures to a burnt watershed.

2. Methods

I obtained field notes from Barry Hecht and tried to relocate his monumented cross-sections with a metal detector at Bluff Camp and Carmel Camp on October 3, 2008. Unable to find his pins, I monumented a total of four new cross-sections within 50 m of those surveyed in *Hecht* (1981) and took GPS coordinates of my pins. There are two cross-sections at each site, one in a riffle and the other in a pool. Access to these sites requires a hike of about eight km over damaged trails with backpacks and survey gear.

I made field observations and conducted most of my baseline analysis at Bluff Camp and Carmel Camp from October 25 – 26, 2008:

1. Riffle cross-sections: I surveyed at a 0.3 m interval using an auto-level.
2. Pool water depths: I recorded water depths along pool cross-sections.
3. Long profile: I surveyed riffle-pool topography along the thalweg using an auto-level.
4. Pebble counts: I randomly selected particles on gravel bars and measured them with a ruler (*Wolman*, 1954), and measured particles along a tape in relatively coarser riffles with a yard stick (Bill Dietrich, personal communication, October 1954).

I resurveyed the riffle cross-sections and surveyed the pool cross-sections at 0.3 m interval from November 10 – 11, 2008, after the first light rain of the winter (Nov. 1 – 3, approximately 2.75 inches).

I performed a flood frequency analysis using the Big Sur River USGS stream gage near Big Sur, California (No. 11143000, drainage area 120 km^2) to determine the bankfull discharge ($Q_{1.5}$) anticipated to cause changes in the upper Carmel River watershed. This is the nearest gage considered representative of the upper Carmel River (B. Hecht, Balance Hydrologics, personal communication, September 2008).

Finally, I reviewed the literature that addresses fire, fish habitat and populations, and watershed management.

3. Results

Bluff Camp is 1 km downstream of Carmel Camp and has a lower slope and finer bed material than Carmel Camp. Bluff Camp has a slope of approximately 0.02 and a D_{50} of 45 mm in the site's riffle cross-section (Fig. 5). Carmel Camp has a slope of approximately 0.03 and a D_{50} of 128 mm in the site's riffle cross-section (Fig. 6). Bluff Camp has plane bed morphology, whereas Carmel Camp has step pool morphology (*Montgomery and Buffington*, 1993). However, both sites are boulder-bedded reaches with grain sizes that vary from 22.6 – 128 mm and have alders, sycamores, and big leaf maples along the banks (Fig. 7).

Bankfull discharge on the Big Sur River is approximately 2,000 cfs (Fig. 8) (Appendix). However, discharge to date on the Big Sur River following the Basin Complex and Indians Fire has not exceeded 200 cfs (December 17, 2008). Therefore, since flows to date on the Big Sur River are an order of magnitude lower than bankfull discharge and the Big Sur River is considered representative of the upper Carmel River, I assume flows to date on the upper Carmel have also been below bankfull discharge. This is consistent with my field observations after the November 1 – 3, 2008 storm. Dry ravel deposits in steep, narrow tributaries near my field sites were intact (Fig. 9), and only minor silt and sand deposits were found in backwater features on the mainstem upper Carmel River. The channel bed geometry and grain size distribution at Bluff Camp or Carmel Camp did not change after this winter event. The changes between the first and second riffle surveys are within the survey accuracy (± 0.1 m over 30 m, e.g. < 1%) (Figs. 10 and 11). The riffles at each location have very irregular surfaces, which make repeat surveys challenging. Furthermore, the pool water depths were comparable between the two field visits. Since the river stage was essentially the same between the surveys, it appears sediment has not yet moved to fill the pools.

4. Discussion

Wildfire is a significant geomorphic process in the upper Carmel River watershed with an estimated pre-1900 frequency of 21 years (*Matthews*, 1989). While fire suppression is generally recognized to decrease fire frequency but increase intensity, it has not altered the likelihood of large fires (>40 km^2) in the Los Padres National Forest because weather is a much stronger control on fire dynamics than fuel characteristics (*Moritz*, 1999). Recent climate change projections suggest the Mediterranean seasonal precipitation regime in California will remain the same (*Cayan et al.*, 2003), while the occurrence of Santa Ana winds may increase during critically dry periods, especially late in the season (*Miller and Schlegel,* 2006). These shifts in the frequency of Santa Anas and increased vegetation drying in future summers strengthen the likelihood for increased fire weather risk in California, which may in turn increase wildfire frequency in the upper Carmel River watershed.

4.1 Baseline geomorphic conditions at Bluff Camp and Carmel Camp

I presume that dry ravel will be the dominant mechanism transporting sediment from the hillslopes to the channel network, although storm flows have not yet been sufficient to mobilize these tributary deposits. Consequently, the baseline conditions in riffle and pools have not changed at Bluff Camp and Carmel Camp. Pre-rain measurements of riffle channel width and depth are similar following the Marble Cone and Basin Complex and Indians Fires. *Hecht* (1981) measured more net fill and scour in riffles at Bluff Camp than Carmel Camp. He did not survey pools, thus pool cross-sections in this study will provide important, new information on how fires affect rearing habitat. Since the slope at Bluff Camp is less than Carmel Camp, I expect Bluff Camp will show a greater geomorphic response. However, if winter rains are insufficient, significant quantities of sediment may get stored in higher-order channels and lead to a temporal disconnect between fire, sediment production, storms, and sediment delivery (*Lave and Burbank*, 2004).

The pre-rain D_{50} in riffle cross-sections is finer now than it was in 1977. Although the same method was employed in both studies, the measurement is location specific and it is possible the pebble counts were performed on different riffles. Facies mapping better describes the grain size distribution in a study area, but local rather than regional processes may result in fining of the bed. I cannot draw conclusions from the difference in baseline riffle grain sizes because fallen trees and shallow landsliding could explain in the finer D_{50} by causing a backwater effect and delivering a pulse of sediment, respectively.

4.2 Lessons from past wildfires in the upper Carmel River watershed

The geomorphic effects of fire depend both on the burn area, burn severity, and the magnitude and timing of winter rains (*Wondzell and King*, 2003). Before the 1977 Marble Cone Fire, there had not been a large fire in the upper Carmel River watershed for 50 years. After the Marble Cone Fire, the estimated remaining canopy cover was less than 10 percent in 42 percent of the watershed, 11 – 50 percent in 20 percent of the watershed, and greater than 51 percent in 38 percent of the watershed (*Hecht*, 1981). Two unusual occurrences contributed to the severity of the burn. First, fuel levels were abnormally high due to the limb breakage sustained during a wet winter and sticky snowfall on January 3, 1974. The effect on fuel loading was especially large in the riparian zone, on terraces, and lower slopes, seldom affected by snowfall (*Hecht*, 1981). Second, the conditions were unusually dry following the severe drought of 1976 and 1977. Rainfall at Big Sur, the nearest long-term weather station, during each of these years were the first and third driest on record (Fig. 12). However, after the fire, total rainfall during the 1977 – 1978 winter was 65% higher than average rainfall. As a result, runoff to and discharge in the upper Carmel River were above normal conditions. Based on the Big Sur River gage, 10 days exceeded bankfull discharge, compared to the average 1.1 days for the period before the fire (*Hecht*, 1981). Furthermore, *Hecht* (1981) reported that deposition in the Los Padres Reservoir during the wet winter following the fire was equal to that occurring during the previous 30 years (Fig. 13).

The 1999 Kirk Complex Fire triggered a very different geomorphic response in the upper Carmel River watershed. This fire was an order of magnitude smaller and burned at lower severity than Marble Cone. It was also followed by a much drier winter than that which followed Marble Cone. Consequently, no significant deposition occurred in the Los Padres Reservoir during the winter following the Kirk Complex Fire (*Smith et al*., 2004). However, since the Basin Complex and Indians Fire has comparable burn area and burn severity as the Marble Cone Fire, it seems the rain this winter will have a profound influence on the post-fire geomorphic response.

4.3 Under what conditions is it appropriate to apply BAER to watershed restoration?

Post-fire changes in the channel bed have a direct effect on suitable salmonid habitat. Steelhead habitat in the upper Carmel River has evolved with frequent episodes of fire. Since steelhead have developed flexible and opportunistic life history strategies, short-term loss of spawning and rearing habitat due to aggradation will not likely result in long-term adverse impacts (*Holdeman and Pyron*, 2008). Conversely, recruitment of spawning gravels and large woody debris will likely result in long-term beneficial impacts (*Holdeman and Pyron*, 2008). Therefore, BAER was not recommended to restore the upper Carmel River watershed for steelhead. Furthermore, the upper Carmel River watershed is generally intact with well-connected aquatic habitat. *Riemen et al*. (1997) demonstrated the importance of connectivity in fish resilience to fire in their study on bull trout (*Salvelinus confluentus*) following fires in the Boise River basin in the early 1990s. They found that the bull trout were probably extirpated in high burn severity areas with drastic channel changes, but reestablished within a year through the return of migratory spawning individuals that were presumably outside the system during the fire. The rapid recovery of this population may not have been possible had migratory spawning individuals encountered difficulty accessing the area.

Thus, where habitats are disconnected and degraded, fires are more of a threat and BAER measures such as erosion control may be required to preserve existing habitat. However, the first priority for watershed management should be restoring connectivity among patches of suitable habitat (*Bisson et al*., 2003). The goal is to maintain aquatic habitats that benefit from inevitable disturbances such has fire, rather than eliminating the threat of the disturbance itself. This goal may not be realistic in highly sensitive areas, thus improved methods are needed to evaluate when, for example, some amount of erosion, debris flows, flooding, and channel change in the short-term is an advantage to aquatic species and their habitats in the long-term. This study addresses the need for better understanding of the natural recovery of aquatic ecosystems following a fire, which is critical for resource managers that need to decide whether to pursue natural recovery or BAER measures.

5. Conclusion

The Marble Cone and Basin Complex and Indians Fires are comparable in size and burn severity, thereby creating a unique opportunity to investigate the effect of winter rains on the geomorphic response of the upper Carmel River watershed. Previous rains this winter have produced flows an order of magnitude less than the estimated bankfull discharge, thus the channel bed geometry and grain size distribution have not changed at Bluff Camp or Carmel Camp. Since Bluff Camp has a lower slope, the site may show a greater geomorphic response than Carmel Camp, if rains induce a response at all. Post-fire changes in the channel bed affect spawning and rearing habitat for threatened steelhead and resident trout. Detailed study of the geomorphic effects of fire on aquatic habitat is needed because fire frequency is expected to increase with climate change and decisions to control or suppress fires can have beneficial as well as detrimental effects on aquatic ecosystems.

Acknowledgements

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Figure Captions

Figure 1. Location map of the Carmel River watershed, showing Los Padres Dam, Bluff Camp and Carmel Camp study sites.

Figure 2. Basin Complex and Indian Fire Burn Severity Map.

Figure 3. Hillslope profile showing the effect of wildfire on vegetation and downslope transfer of sediment to stream channel by dry ravel (modified from *Florsheim et al.,* 1991).

Figure 4. Bed configuration and high-water marks during the fill and scour cycle following the Marble Cone Fire (*Hecht*, 1981).

Figure 5. Bluff Camp long profile from survey on October 25, 2008.

Figure 6. Carmel Camp long profile from survey on October 26, 2008.

Figure 7. Facies maps of Bluff Camp and Carmel Camp with D_{50} for select riffles and gravel bars.

Figure 8. Big Sur River Flood Frequency Curve based on USGS Gage 11143000, Peak streamflow 1950 – 2007.

Figure 9. Photograph of dry ravel in tributary to upper Carmel River (October 26, 2008).

Figure 10. Bluff Camp channel bed and water surface elevations from riffle cross-section survey on October 25 and November 10, 2008.

Figure 11. Carmel Camp channel bed and water surface elevations from riffle cross-section survey on October 26 and November 11, 2008.

Figure 12. Big Sur State Park Annual Rainfall Totals by Water Year.

Figure 13. Los Padres Reservoir: Pre-Marble Cone Fire, May 14, 1971 (left) and post-Marble Cone Fire, June 7, 1978 (right) (photos courtesy of ABG and USFS).

Figures

Figure 1.

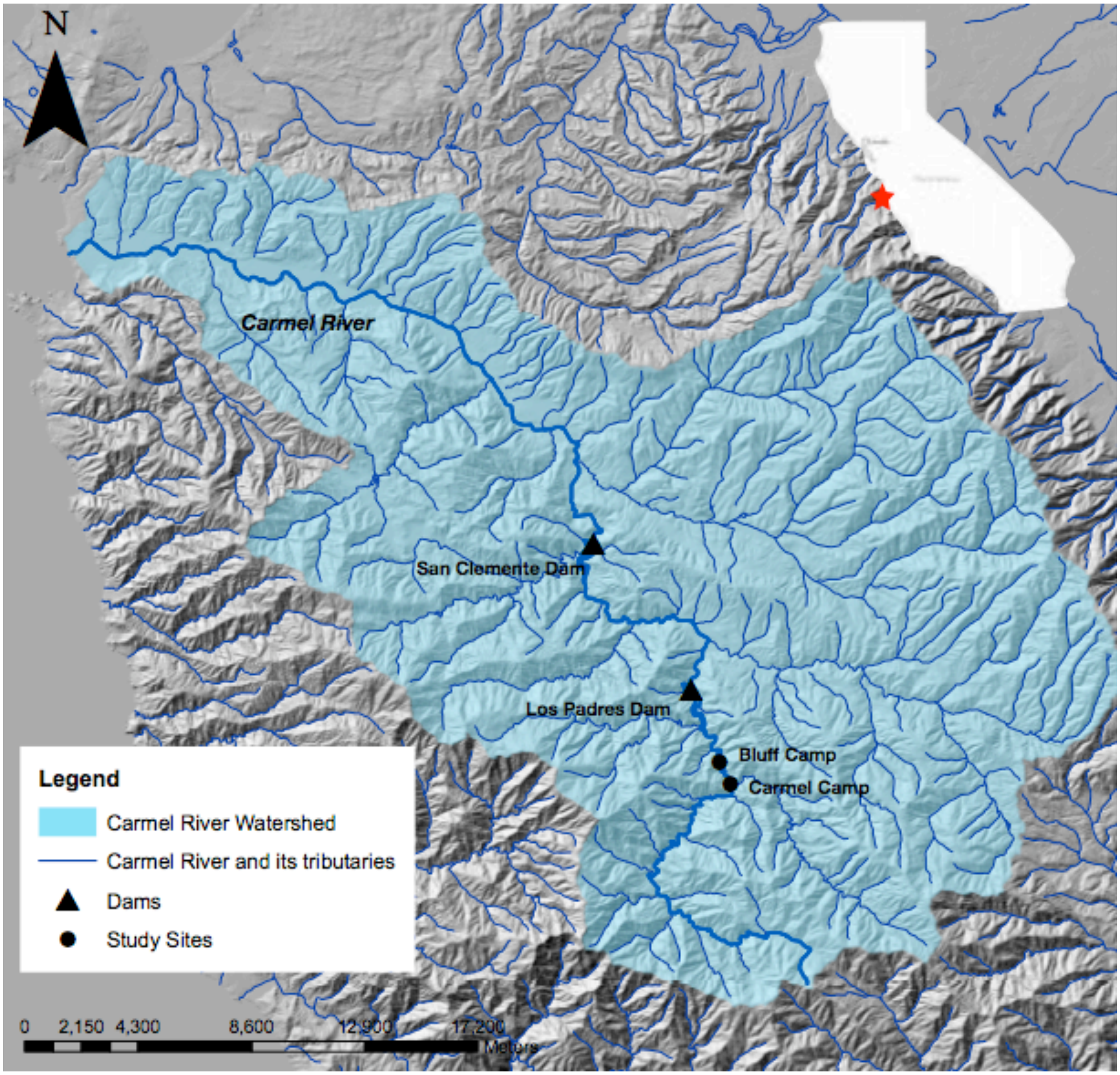


Figure 2.

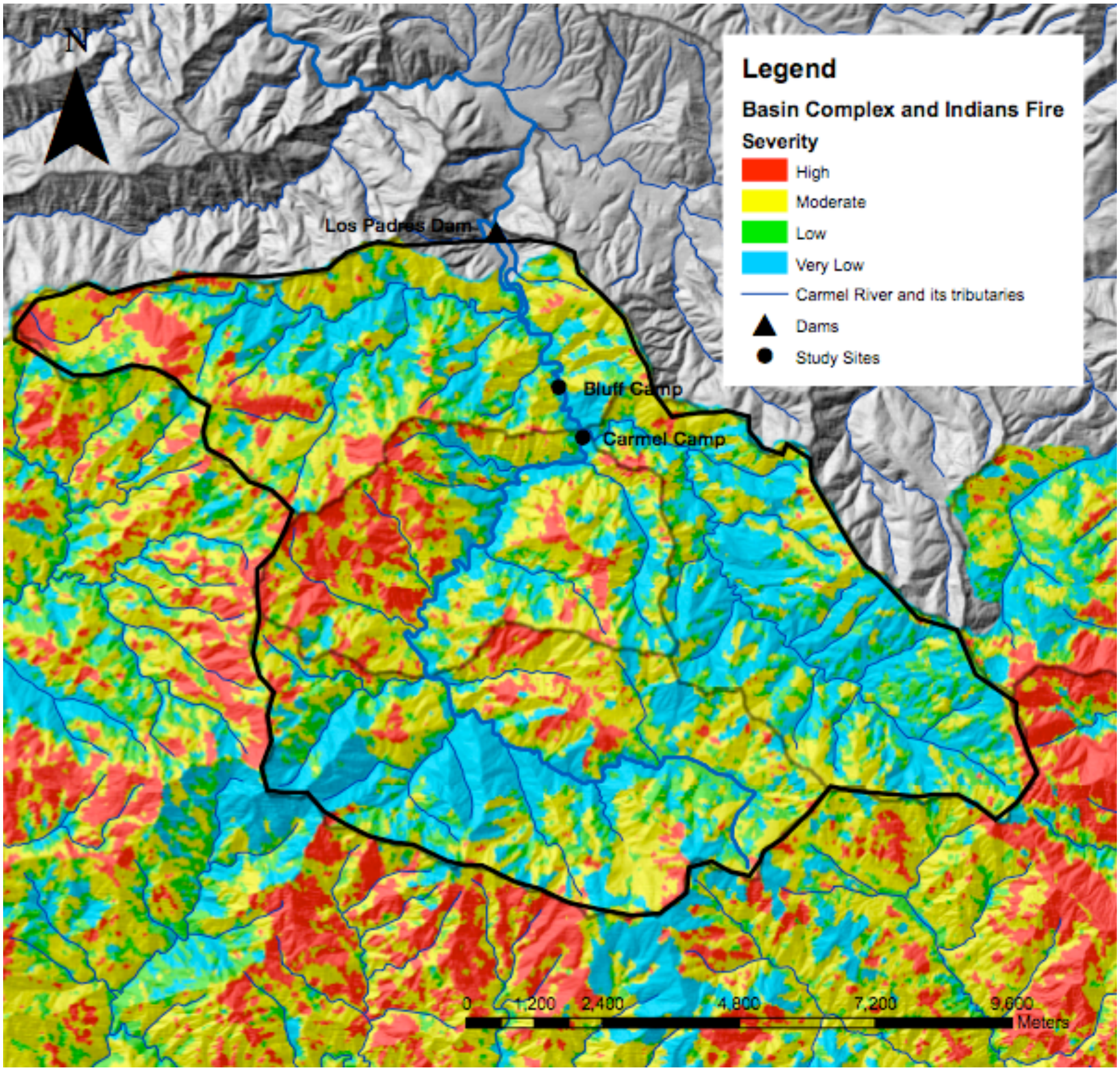

N
Legend
Basin Complex and Indians Fire
Severity
🟥 High
🟨 Moderate
🟩 Low
🟦 Very Low
Carmel River and its tributaries
▲ Dams
● Study Sites
Los Padres Dam
Bluff Camp
Carmel Camp
0
1,200
2,400
4,800
7,200
9,600
Meters

Figure 3.

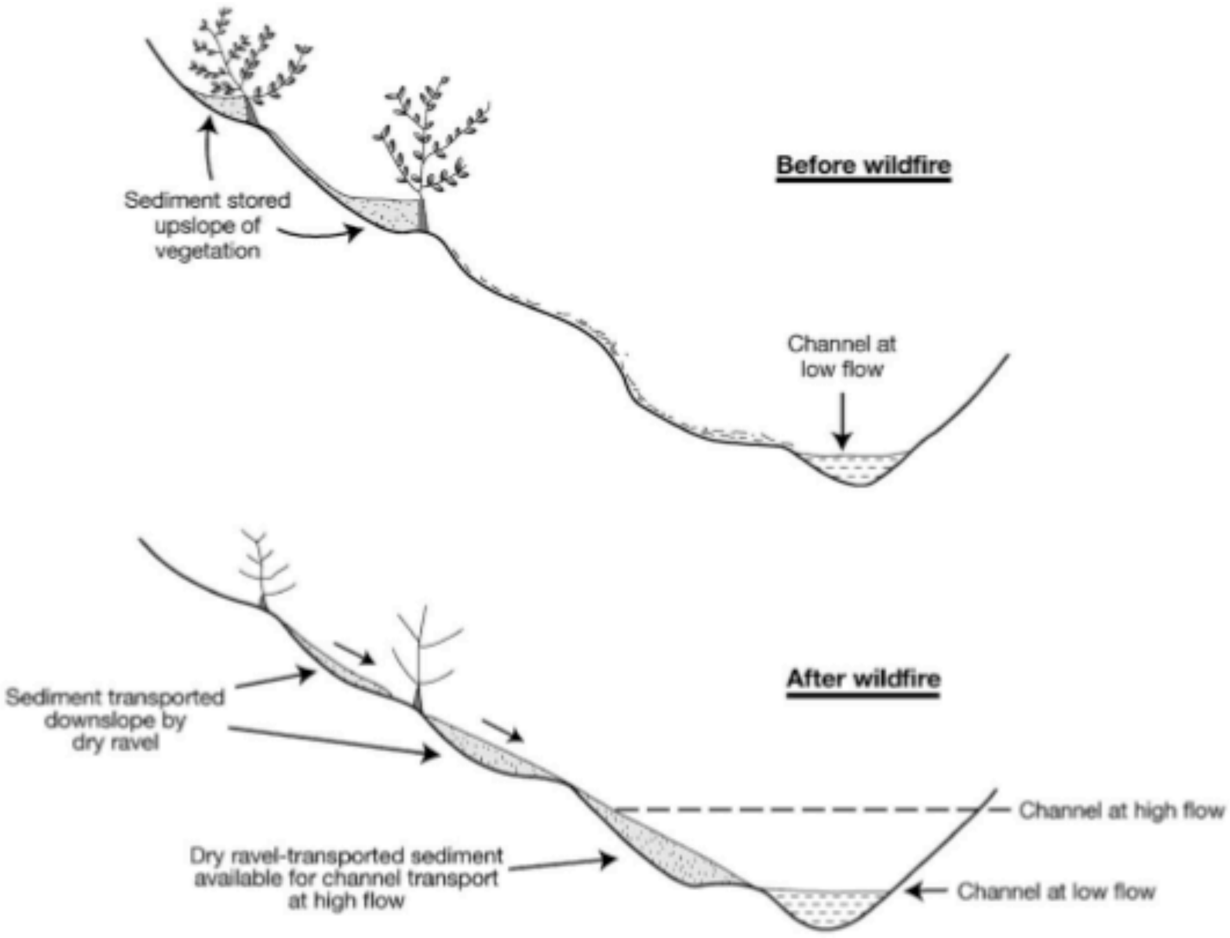

Before wildfire
Sediment stored upslope of vegetation
Channel at low flow
After wildfire
Sediment transported downslope by dry ravel
Channel at high flow
Dry ravel-transported sediment available for channel transport at high flow
Channel at low flow

Figure 4.

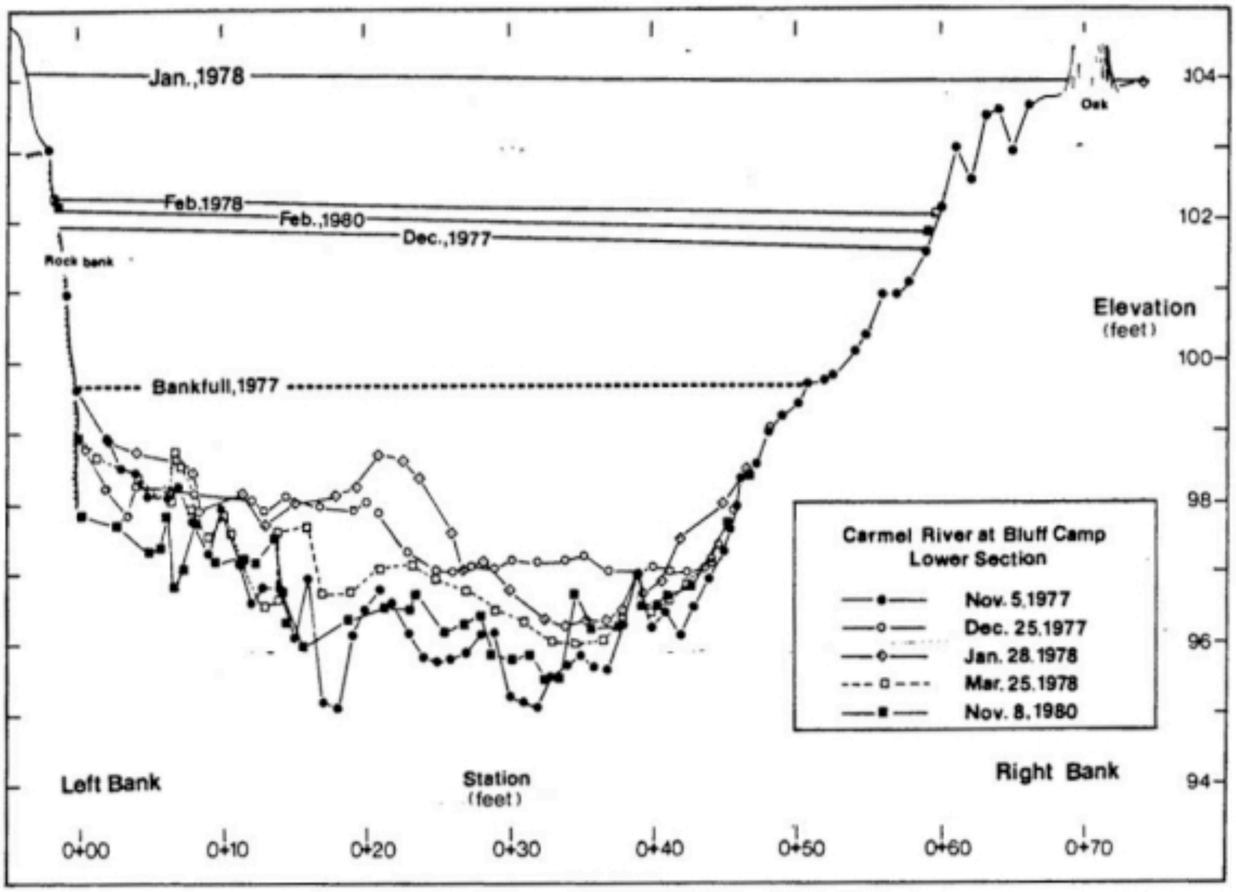

Jan.,1978
Feb.1978
Feb.,1980
Dec.,1977
Rock bank
Bankfull,1977
Oak
Elevation (feet)
104
102
100
98
96
94
Carmel River at Bluff Camp
Lower Section
Nov. 5,1977
Dec. 25,1977
Jan. 28,1978
Mar. 25,1978
Nov. 8,1980
Left Bank
Station (feet)
Right Bank
0+00
0+10
0+20
0+30
0+40
0+50
0+60
0+70

Figure 5.

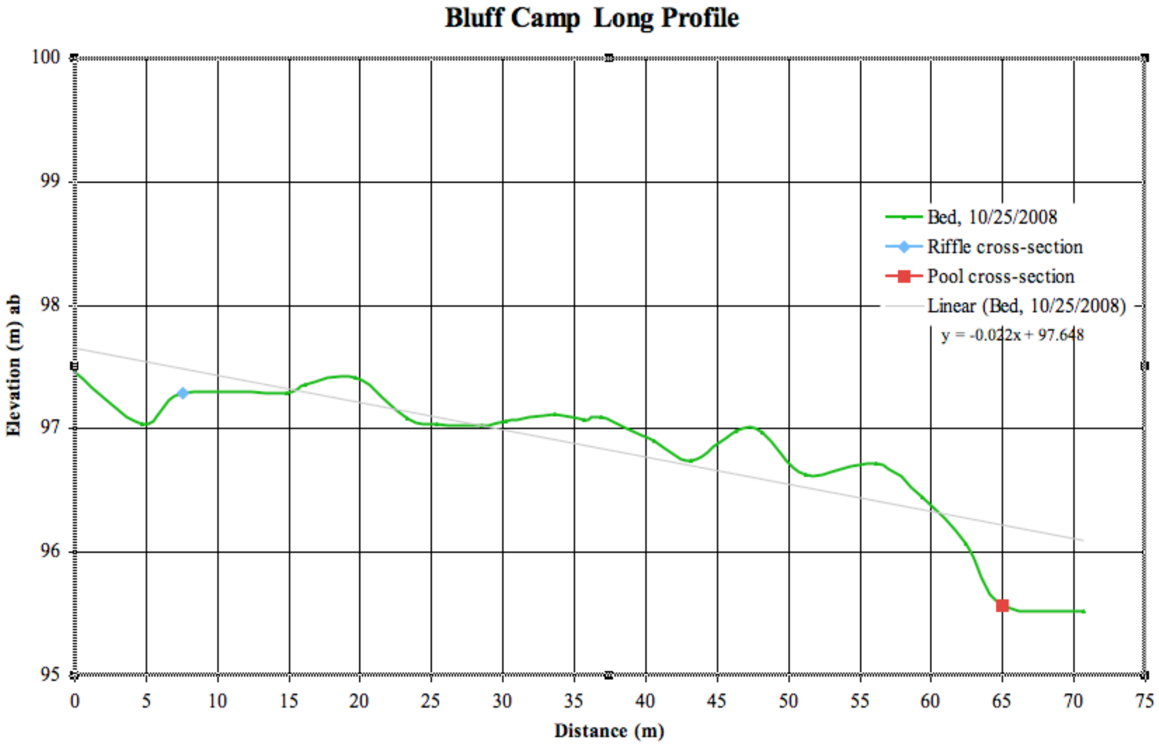


Figure 6.

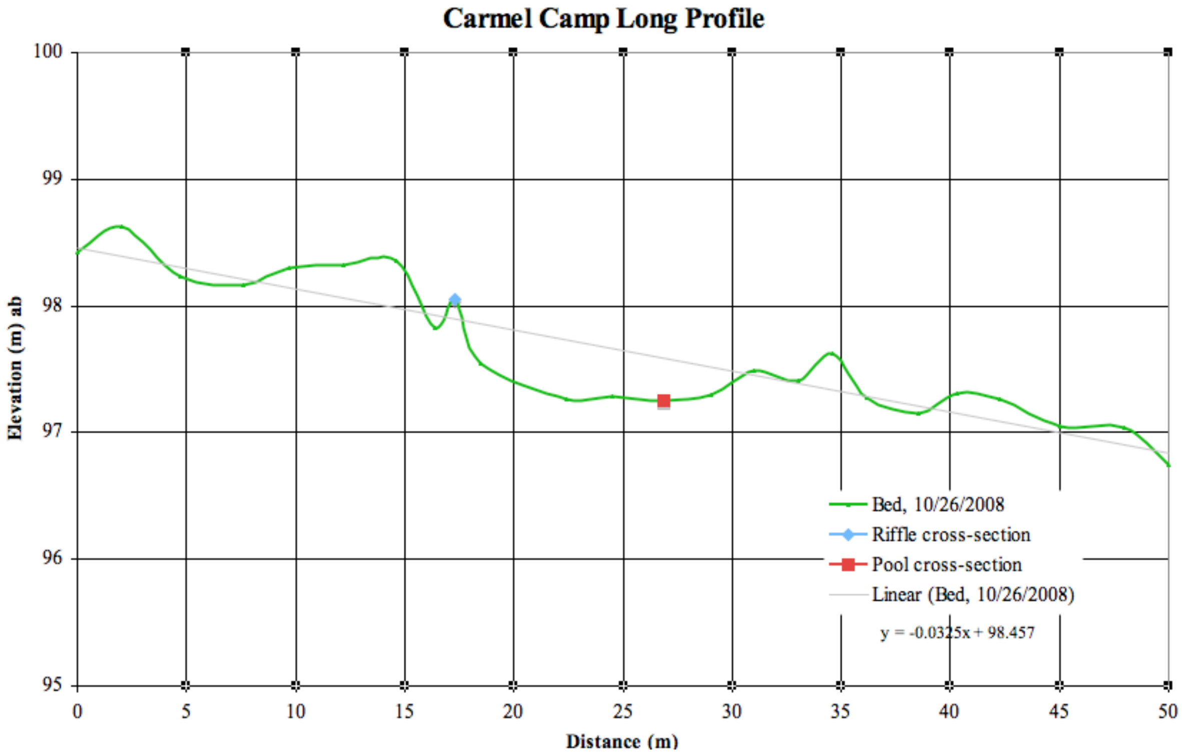


Figure 7.

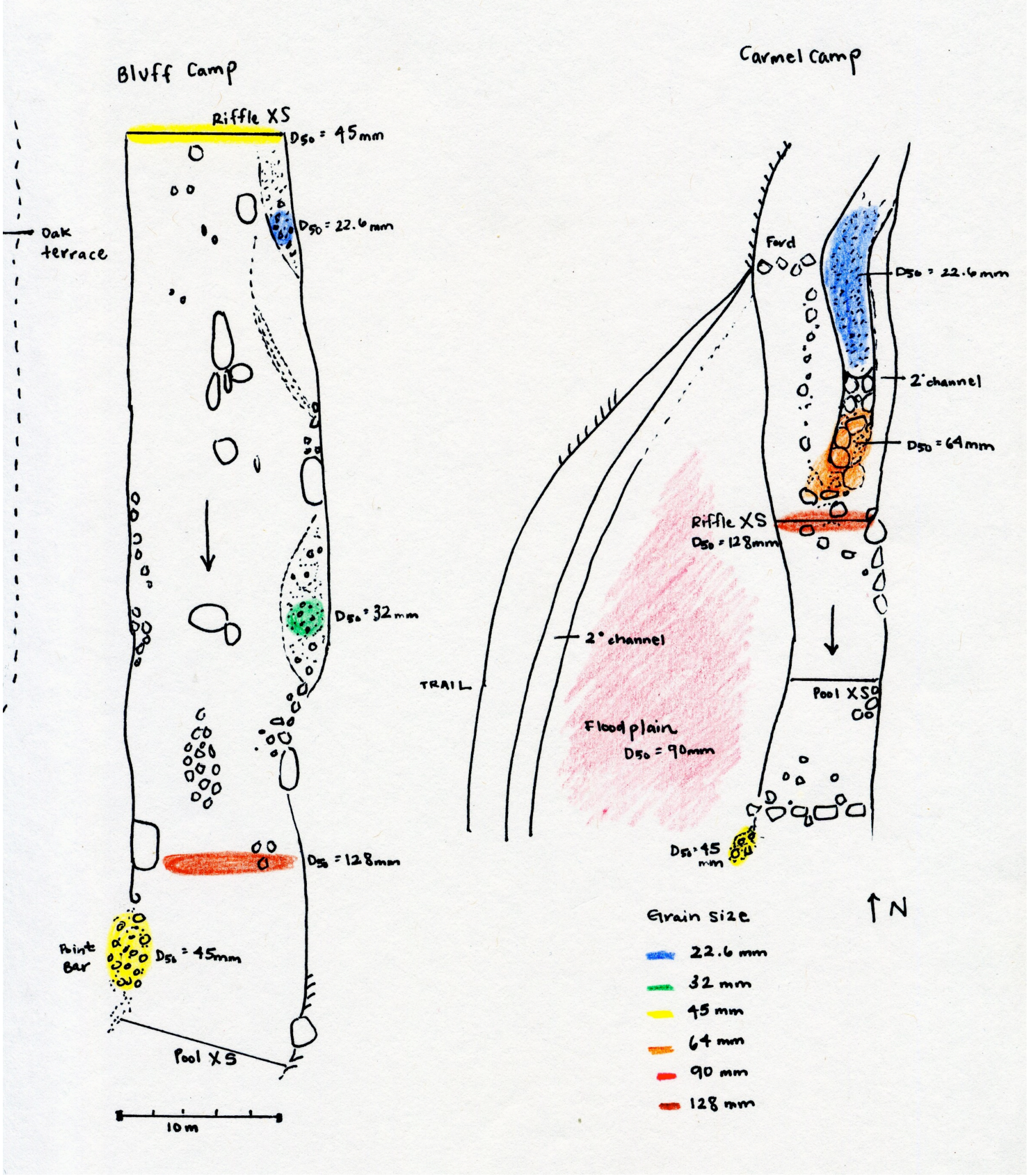
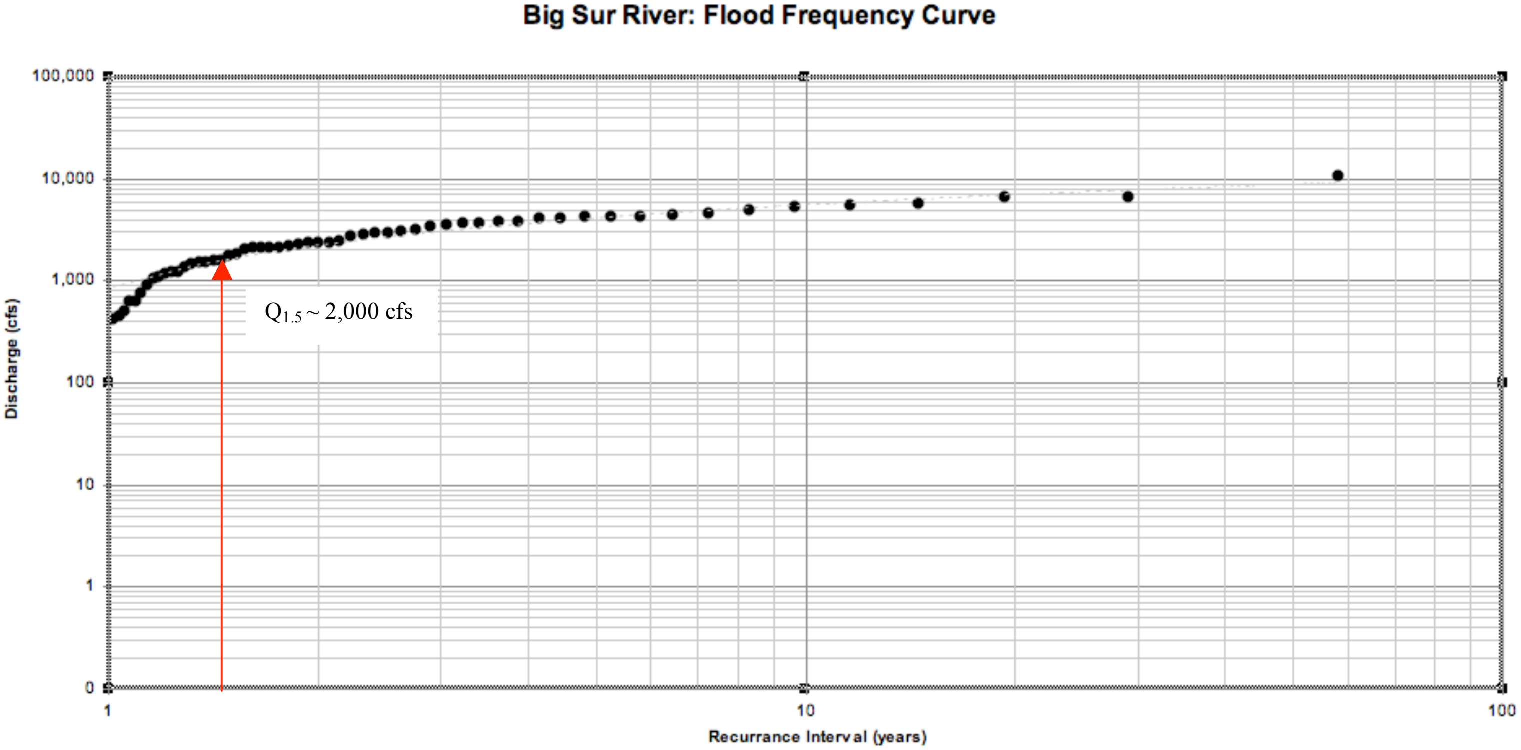

Bluff Camp
Riffle XS
D50 = 45mm
D50 = 22.6 mm
Oak terrace
D50 = 32 mm
D50 = 128mm
Point Bar
D50 = 45mm
Pool XS
10m
Carmel Camp
Ford
D50 = 22.6mm
2° channel
D50 = 64mm
Riffle XS
D50 = 128mm
2° channel
TRAIL
Flood plain
D50 = 90mm
Pool XS
D50 45 mm
Grain size
22.6 mm
32 mm
45 mm
64 mm
90 mm
128 mm
N

Figure 8.



$Q_{1.5}$ ~ 2,000 cfs

Figure 9.

Figure 10.

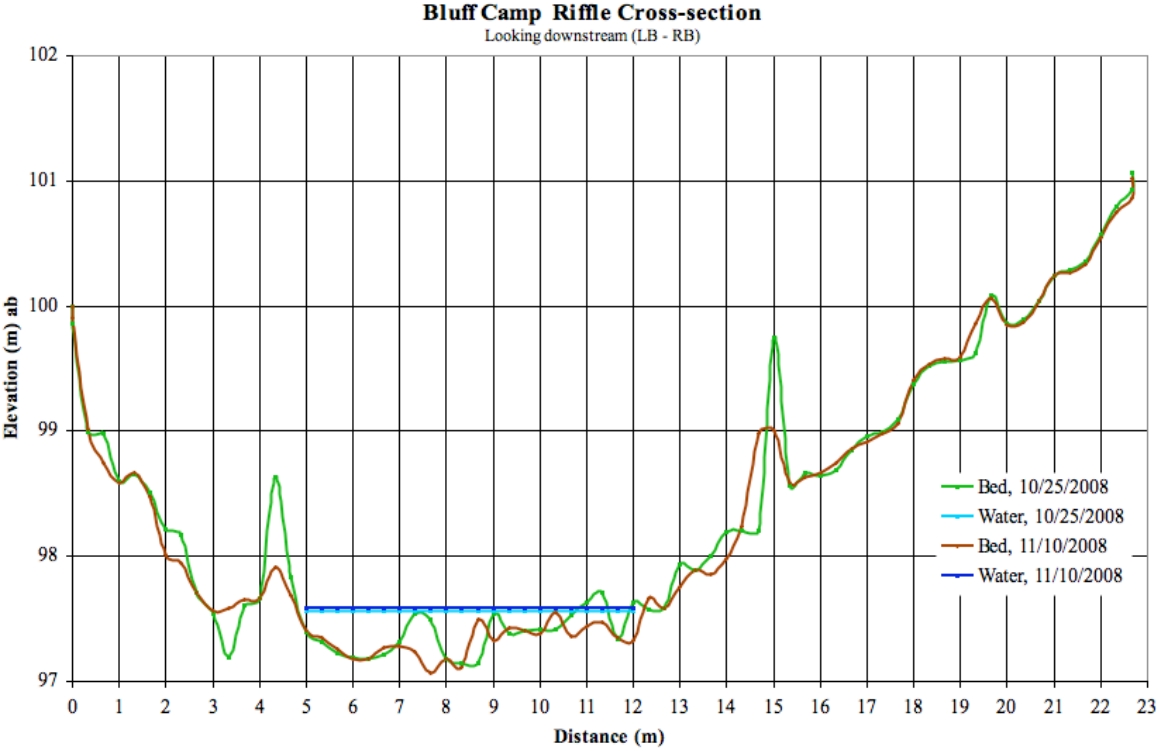


Figure 11.

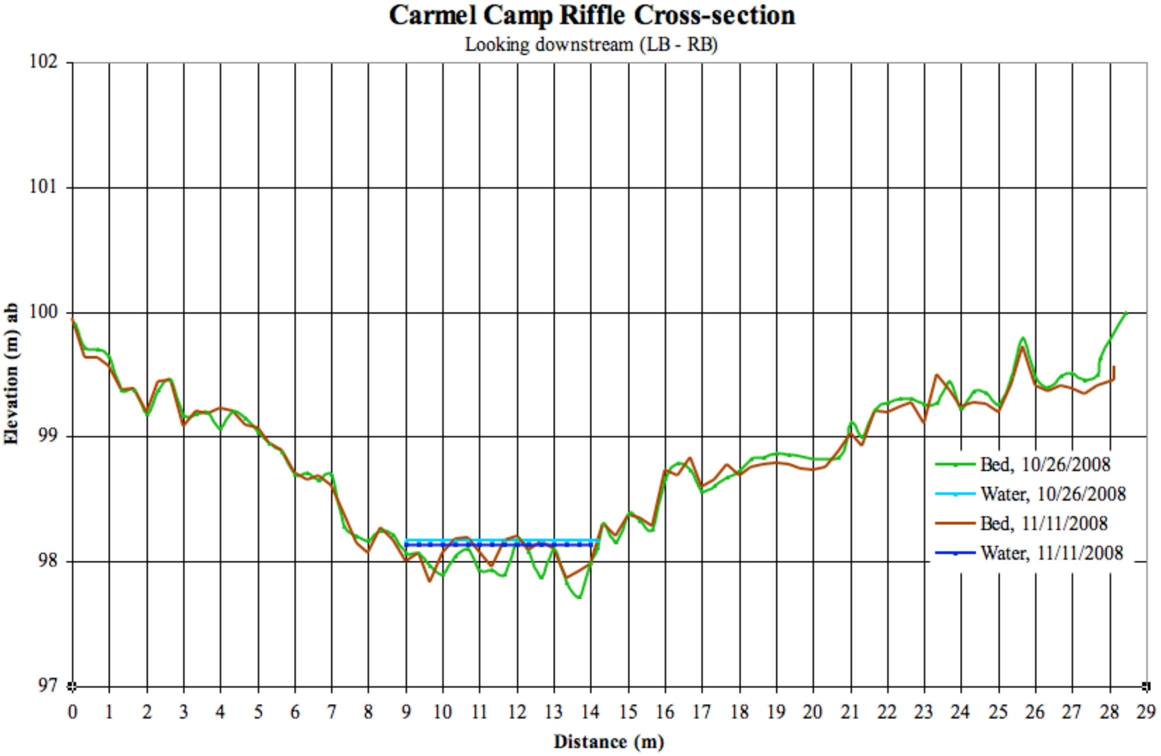


Figure 12.

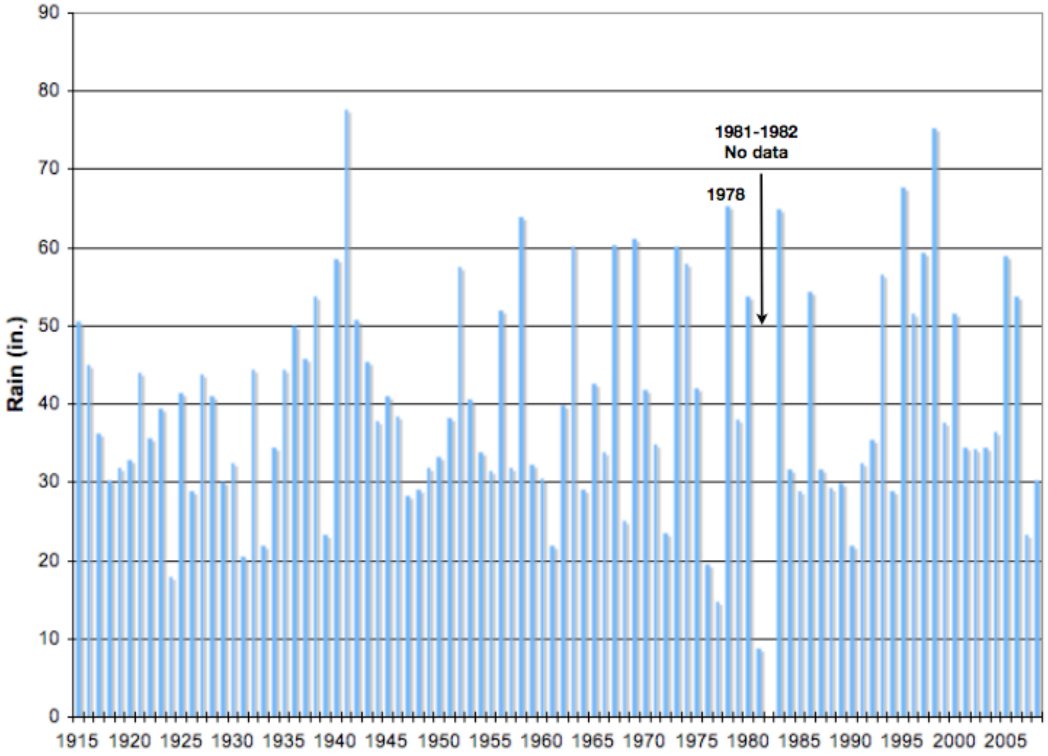
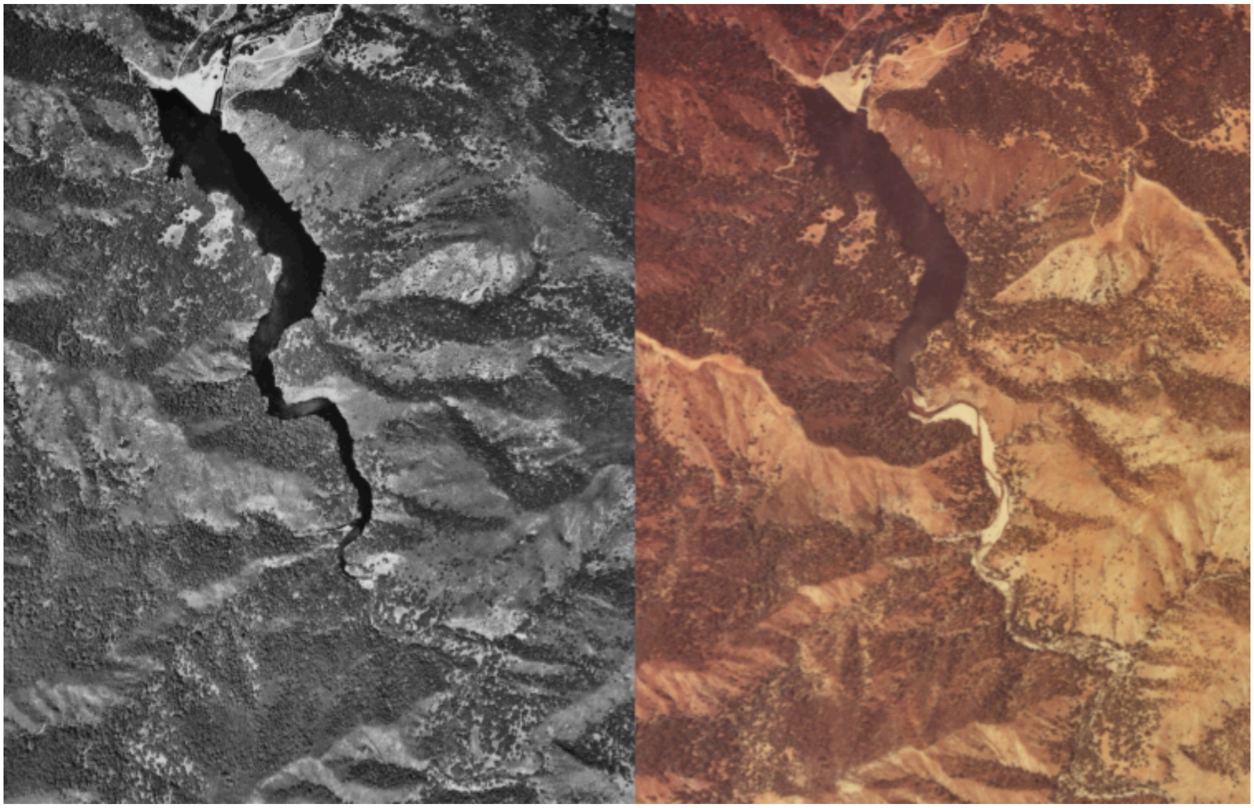


Figure 13.



APPENDIX

Flood Frequency Analysis, Big Sur River USGS stream gage near Big Sur, California (No. 11143000)

Water Year	Date	Gage Height (ft)	Streamflow (cfs)	Rank	RI
1978	Jan. 05, 1978	14.3	10,700	1	58.00
1995	Mar. 10, 1995	11.71	6,690	2	29.00
1998	Feb. 03, 1998	11.64	6,590	3	19.33
1958	Apr. 02, 1958	11.56	5,680	4	14.50
1963	Feb. 01, 1963	11.23	5,400	5	11.60
1956	Dec. 23, 1955	11.05	5,220	6	9.67
1997	Jan. 01, 1997	10.58	5,000	7	8.29
1967	Dec. 06, 1966	10.3	4,510	8	7.25
2000	Feb. 14, 2000	10.18	4,440	9	6.44
1986	Feb. 17, 1986	9.8	4,280	10	5.80
1951	Nov. 19, 1950		4,200	11	5.27
2006	Dec. 31, 2005	9.99	4,190	12	4.83
1952	Jan. 14, 1952	9.906	4,150	13	4.46
1982	Jan. 05, 1982	9.63	4,030	14	4.14
1969	Jan. 26, 1969	9.53	3,820	15	3.87
1970	Jan. 16, 1970	9.5	3,790	16	3.63
1983	Dec. 22, 1982	9.25	3,670	17	3.41
1980	Jan. 13, 1980	9.27	3,670	18	3.22
2003	Dec. 16, 2002	9.47	3,500	19	3.05
1993	Jan. 14, 1993	9.25	3,400	20	2.90
1962	Feb. 15, 1962	8.8	3,160	21	2.76
1996	Feb. 19, 1996	9.07	3,000	22	2.64
1987	Feb. 13, 1987	8.56	2,960	23	2.52
1953	Dec. 07, 1952	8.52	2,920	24	2.42
1973	Feb. 11, 1973	8.36	2,790	25	2.32
1975	Feb. 02, 1975	8.37	2,780	26	2.23
1985	Feb. 08, 1985	8.06	2,460	27	2.15
1991	Mar. 04, 1991	7.96	2,370	28	2.07
2005	Mar. 22, 2005	8.5	2,340	29	2.00
1981	Jan. 27, 1981	7.76	2,330	30	1.93
1960	Feb. 01, 1960	7.72	2,280	31	1.87
1999	Feb. 09, 1999	8.35	2,180	32	1.81
2002	Dec. 02, 2001	8.31	2,140	33	1.76
1965	Jan. 06, 1965	7.37	2,100	34	1.71
1974	Mar. 02, 1974	7.57	2,100	35	1.66
1992	Feb. 14, 1992	7.66	2,090	36	1.61
1957	Feb. 24, 1957	7.43	2,010	37	1.57
2004	Feb. 25, 2004	8.02	1,850	38	1.53
1984	Dec. 25, 1983	7.25	1,730	39	1.49
1971	Nov. 29, 1970	6.8	1,600	40	1.45
1989	Dec. 24, 1988	7.05	1,560	41	1.41
1979	Nov. 21, 1978	6.78	1,510	42	1.38
2001	Mar. 04, 2001	7.62	1,500	43	1.35
1964	Jan. 20, 1964	6.48	1,470	44	1.32

Riffle Pebble Counts

Size (mm)	Bluff Camp	Carmel Camp
2050	**0**	0
1450	**0**	0
1024	**0**	4
725	**7**	2
512	**9**	8
360	12	10
256	3	11
180	7	6
128	6	14
90	0	9
64	5	7
45	6	9
32	6	4
22.6	12	5
16	6	3
11.3	3	3
8	8	4
4	6	1
<4	6	1
Total	**102**	**101**

1990	Feb. 16, 1990	6.8	1,360	45	1.29
1968	Jan. 30, 1968	6.25	1,230	46	1.26
1972	Dec. 25, 1971	6.23	1,220	47	1.23
1959	Sep. 19, 1959	6.22	1,170	48	1.21
1994	Feb. 19, 1994	6.78	1,100	49	1.18
1954	Jan. 17, 1954	5.94	1,050	50	1.16
1966	Nov. 17, 1965	5.73	918	51	1.14
1961	Dec. 01, 1960	5.45	760	52	1.12
2007	Feb. 10, 2007	6.39	636	53	1.09
1955	Dec. 02, 1954	5.18	630	54	1.07
1976	Feb. 29, 1976	4.99	496	55	1.05
1988	Dec. 06, 1987	5.5	451	56	1.04
1977	Jan. 02, 1977	4.78	415	57	1.02