Critique of Post-Burn Management Measures Taken in Santa Clara Canyon

By Reid Whittlesey for Stream Dynamics, Inc.   March 1, 2017

The Las Conchas Fire affected significant change to the ecological condition of Santa Clara Creek watershed. Historic bounds of soil instability were well surpassed following the burn, and erosion processes accelerated to an unprecedented rate. Major hydrograph changes followed, as well as major alteration of channel forms, increased sediment transport rates, and the growth of alluvial fans. Thousands of dead and unstable trees within the flood plain created a substantial addition of large woody debris, forming extensive log jam complexes. Management programs soon began to mediate the effects of the fire. While intended to mitigate the impacts of the fire, many of the repercussions were widespread and did not overall benefit the health and function of the watershed. This report seeks to discuss how some of these management practices were deleterious to overall watershed health through providing a non-partisan scientific discussion of the ecological trajectory following an intense fire and how differing practices could have benefited the overall health and function of the watershed.

Following the Las Conchas fire, hydrophobic soil and incinerated vegetation – including both overstory and groundcover – contributed to the occurrence of high flows and erosion rates. These factors significantly altered the pre-fire conditions of Santa Clara Creek and its tributaries. The intensity of the burn was such that in many areas 100% mortality of trees occurred and ground cover vegetation was diminished to functionally zero. In the year following the burn many parts of the watershed experienced sheet-flow runoff rates that likely exceeded any within recorded history. Hillsides began to rill, rills became gullies, and valley bottoms that were previously grassed-in swales became deeply incised channels.

Pre-existing landuse practices that impacted the watershed – particularly logging, road construction, and grazing – contributed to the deleterious effects of the fire, exacerbating its effects and leading to heightened erosion rates of hillsides and channels through concentrating flow and surface disturbance making slopes more prone to erosion. While the ecological trajectory was significantly altered by the fire alone, natural processes were in place to reduce erosion over time, increase soil development, and regain lost base-elevation levels of the channel. Post-fire management actions worked largely to inhibit these natural processes and negatively impacted the condition of the watershed on a much greater timeline than would have naturally occurred without management.

Large Woody Debris: Formation, Processes, and Impacts

Post-burn a combination of the tree mortality, de-stabilized substrates, and high flows mobilizing a large sediment bedload lead to downed and dead trees and logs, known collectively as large woody debris (LWD), to build up within the channel and floodplain. Subsequent flows rearranged the material into dense logjams. Sediment became trapped behind jams and the channel began to quickly morph shape and characteristics, increasing in base elevation and re-accessing floodplains and benches that were lost during the immediate incision following the fire. Before these processes could stabilize, a massive program of LWD removal began, spear-headed by an initial re-opening of the road up the canyon. Over the next several years, most of the LWD within the channel and floodplain was systemically extracted. Logjams were cut apart and removed, and even standing trees – both alive and dead – that were within the floodplain were felled and removed. These actions altered the ecological state beyond any that would naturally occur in a wild setting, subsequently retarding the return to ecosystem functionality and health.

Removal of LWD has numerous deleterious impacts. Over time logjams become stable and exhibit numerous influence on hydraulic systems, functioning to reduce the hydrograph variance by slowing flows, increasing infiltration rates and reducing the severity of peak flows. This is accomplished through reducing the velocity due to increased channel friction and floodplain access at logjam sites – which catch a wide range of sediment and debris sizes. This subsequently raises the water table and allowing flows to activate flood plains and terraces during high flow events , which diffuses concentrated energy and promotes aquifer recharge. Removal of LWD results in elevated erosion rates and the eventual abandonment of flood plains as channel incision develops. For example, a stream that had LWD removed as part of a study experienced a 4x increase in bedload transport and increase in bank erosion as a result[1]. In another study it was found that while LWD composed only 2% of the channel, it was responsible for 50% of the shear stress, thereby reducing the shear stress on bedload which in turn reduces erosion and channel incision[2]. In Santa Clara Creek the post-fire LWD within the channel was likely the most active force in achieving stability of the system.

Along with a drop in base-elevation of the channel following LWD removal, other significant alterations occurred. Channel complexity diminished, flood-plains were lost, and stream length lessened. Without LWD to catalyze the formation of step-pool complexes and geomorphically unique pool-riffle-glide systems, the stream achieved a state of repeated patterns as it reacted to lessened inputs. Bedrock, hillslopes, large boulders, and poorly placed road crossings became the sole impetus for breaking meander patters. As a result the stream straightened, channel slope and water velocity increased, and further incision made utilization of pre-fire floodplains unlikely except during extremely high flows. Without significant channel complexity and access to a floodplain, the stream's value as a biologic and water-source resource is greatly lessened. Continuation of the current trajectory and management practices will likely result in impairments to the stream and its inability to function as a high quality cold water aquatic habitat.

Under the current conditions the amount of sediment mobilization and transport is very high. There are no impediments to the continued transport of sediments, as re-vegetation of the channel is slowed to the point of irrelevancy and few opportunities for natural LWD additions exist. While the mobilized sediment itself is not overtly problematic, it is providing a substantial addition to the filling of reservoirs on the Rio Grande. Lessening erosion in the tributaries due to restoration actions and natural stabilization processes will reduce the sediment load in Santa Clara Creek, but sediments within the main channel itself will continue to be mobilized until the channel-bed composition favors a larger, more stable size. Fine sediments will continue to be flushed downstream in this system.

Alluvial Fans: Response to LWD Presence and Removal

Large volumes of sediment was transported by numerous tributaries of Santa Clara Creek following the fire as massive erosion rates were experienced throughout the watershed. As sediment from tributaries approached Santa Clara Creek, alluvial fans that were down-cut during the initial erosion immediately post-fire began to re-form. With the high friction coefficient of the channel caused by the LWD and the increasing base elevation due to high sediment deposition rates, alluvial fan development was rapid. Channel elevation was raised until it escaped the confines of the incised banks and re-activated the fan, as the increased base elevation of Santa Clara Creek imposed high deposition rates at the tributary

---

1 Smith, R. D., Roy C. Sidle, and P. E. Porter. "Effects on bedload transport of experimental removal of woody debris from a forest gravel- bed stream." *Earth Surface Processes and Landforms* 18.5 (1993): 455-468.

2 Manga, Michael, and James W. Kirchner. "Stress partitioning in streams by large woody debris." *Water Resources Research* 36.8 (2000): 2373-2379.

confluence. Deposition across the fan would result in further fan growth, increasing both its width and slope. Under unaltered circumstances or aided by restorative management, a healthy and functioning alluvial fan system would have likely been restored within the decade, leading to increased water storage and water quality. However, due to the management actions that were taken, the alluvial fans that were re-forming incised again to below pre-fire elevations, meeting the new loss in base elevation of Santa Clara Creek following the LWD removal. This development will be hard to reverse, not only due to the height gain required to achieve functionality, but also due to the absence of a mobile sediment supply of the necessary volume as hillsides and tributaries throughout the watershed have begun to stabilize.

Channel Characteristics, Soil Development, Plant Regeneration

Without the LWD component, the required shear-stress is met by bed-load mobilization and bank erosion. Lacking complexity and a stable high friction coefficient within the channel, fine sediments are flushed downstream. Soil development within the floodplain and riparian area as a whole remains extremely low, with only isolated sites adequately functioning as low-disturbance refugia for clays, silts, fine sands, seeds, and other organic components to settle. Safe-sites for plant recruitment within the floodplain are also extremely limited, which is evident by the observed low vegetation recruitment rates. Without a complex woody component most soil building materials that enter the water column are flushed downstream. As a result, re-vegetation rates will likely remain very low for a much greater time than in an unaltered setting.

Channel complexity has also been much reduced by LWD removal. Rather than exhibiting a pool/riffle system with an accessible and frequently active floodplain, Santa Clara Creek frequently runs several meander lengths without a still water pool. This is due in part to high bedload mobilization experienced by the system because the lack of stable components to add to shear-stress rates and the lack of woody debris to instigate scour, pool development, and aggradation. Because of this, Santa Clara Creek remains in an extremely erosive state. If additions of sediments by tributaries were to halt, the main channel will incise rapidly during a high flow event.

Benefits of LWD, An Alternate Management Trajectory

Had the LWD been left in place, the return of ecological health and function to Santa Clara Creek watershed would have been a much shorter process, resulting in substantial ecological gains rather than losses. Dense, stable log jams would have been formed, catching sediments on the upstream side and diffusing the water drop downstream through the complex size component and high friction rates, negating the common tendency of sediment catchment structures to result in incision on the downstream side. Over time the base elevation of the stream would increase as the widespread placement of LWD throughout the length of the stream would equalize gains. Tributaries would adjust to the increased base elevation through the slope of the alluvial fan diminishing, in turn leading to increased deposition rates in the reach and eventually tying in to the new base elevation throughout their entire length.

The new elevated position in the valley bottom caused by sediment catchment facilitated by LWD would provide opportunities for increased wetland habitat development and subsurface water storage. The increased channel elevation would cause an increase in frequency and duration of floodplain activation, resulting in higher infiltration rates to the aquifer. In turn this would contribute to a moderated hydrograph, alleviating threats to downstream structures. The magnitude of high flows would be diminished through diffusion across the floodplain with an increased infiltration rate, and low-flow volume would increase through the moderated perennial release of groundwater into the channel.

Soil development rates within a system influenced by LWD would be high, as decomposing LWD provides a large component of organic material, and the high friction coefficient of the channel would catch other nutrient rich soil building components such as leaves, lichens, and mosses. The LWD, sticks, and other detritus caught in log jams act as a medium for algae and fungi, both important in soil development and nutrient cycling and availability processes.

Physical impacts to the channel characteristics are also impacted by LWD, with LWD dams causing a great increase in flow complexity and sediment sorting. This in turn provides opportunities for recruitment of plants, and specific use habitats for aquatic animals. In an unaltered system laden with complex LWD, deposited sediments would be sorted from fine silts and clays in very slow flood-plain backwaters, gravels and sands in developing point bars, to cobbles and boulders in scours and riffles. This complexity and diversity of channel characteristics has been shown to have great importance in many riparian processes, from recruitment of cottonwood seedlings to increased hatching success rates of native fish.

Suggested Alternate Management Practices Following Severe Burns

LWD should remain in the channel with removal conducted as necessary under individually assessed circumstances only. Alternate methods should be investigated to reduce floatable debris hazards to downstream structures, such as large cable-netting structures as seen across the mouth of several tributaries. Roads and road crossings should be placed with consideration given to the stream and floodplain. This will result in a more stable and permanent roadway, with lower risk of blow-out and greatly lessened maintenance costs over time while also allowing for development and growth of valuable riparian habitat.

To effectively mediate the negative impacts of the fire, immediately following the end of the first monsoon season a broad use of conventional restoration practices should have been put into place. Tactical restoration teams deployed into the most damaged tributaries soon after the fire could lessen soil loss and flashy flood events and promote a faster trajectory towards ecological stability. Installation of in-stream structures such as post-vanes, cross-vanes, media-lunas, and zuni bowls would limit soil loss, promote induced meandering, and stabilization of sediment loads. Large-scale plantings of willow and cottonwood along the channel would ensure lasting stabilization of the channel and could be placed so that induced meandering and sediment catchment would be encouraged. These methods work with natural processes and could have enhanced the ecological condition of the watershed while functioning to achieve the desired results of flood control and sediment catchment.

In conclusion, much of the significant erosion that occurred post-fire could have been avoided if resources had been allotted towards techniques that aided the function of ecological processes rather than combating them. An ecologically based management strategy for Santa Clara watershed could still have accomplished the necessary actions to maintain the safety of the Pueblo and its residents while over time enhancing the condition of the watershed and its value as a water source.