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Post-fire Channel Changes of Muddy Hollow Creek, Point Reyes National Seashore

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Abstract

The Mt. Vision Fire of October 1995 burned almost 13,000 acres of wilderness in Point Reyes National Seashore, about 31 miles northwest of San Francisco, CA. The 3.2 sq. mile watershed of Muddy Hollow Creek was almost entirely burned by the fire. The isolated nature of the watershed provides an excellent location to study post-fire watershed response in Northern California.

For the two years following the fire, 1996 and 1997, Collins and Ketcham (2001) documented changes to Muddy Hollow Creek and the watershed. They observed the formation of an alluvial fan and braided channel form in the lower reach. They estimated the minimum average sediment load during these two years was 2,626 tons/sq mile/year. They noted that sediment deposition during the second year after the fire was 2.7 times higher than the previous year. This was due to bed erosion and incision of the middle reach due to large amounts of woody debris falling into the river. The middle reach became entrenched due to high flows in 1996. They hypothesized that as the sediment load and flow decreased the lower reach would return to a single channel and an extensive alder forest would grow over the fan.

In October 2004, we conducted the first follow-up survey since Collins and Ketcham. We surveyed three cross-sections in the middle reach of Muddy Hollow Creek and documented changes in vegetation and geomorphology from repeat ground and aerial photography in the middle and lower reaches. We did not observe significant changes in channel depth in the middle reach. We observed an increase in vegetation and alder forest growth in the lower reach of the creek as hypothesized by Collins and Ketcham. Much of the woody debris in the middle reach is still decaying, but ground cover may slow the rate of erosion seen in the first two post-fire years. Consequently, we hypothesize that less sediment will be deposited in the lower reach allowing the lower reach to form a more defined channel.

Photo points and survey data that we collected can be reproduced to further analyze the post-fire response of the watershed.

Introduction

Problem Statement

The purpose of this study is to identify and document continuing changes in the geomorphology of Muddy Hollow Creek (MHC) in Point Reyes National Seashore (Figure 1) following the October 1995 Mt. Vision fire. Post-fire erosion control response in California is based upon landscape response of Southern California watersheds even though climate, vegetation, and geology vary throughout the state (Collins and Ketcham 2001). MHC is an excellent location to study a Northern California watershed's response to wildfire virtually all of the watershed lies within the National Seashore and burned at one time (National Park Service 1997).

Muddy Hollow Creek Watershed

MHC drains 3.2 square miles (sq mi) from Inverness Ridge (elev 1076 feet) to sea level at Estero de Limantour. From the headwaters, the mainstream MHC flows for 7,200 ft through Cretaceous-aged granodiorite and granite, 400 ft through Laird Sandstone, 1600 ft through the Middle to Upper Miocene-aged Monterey Formation, and downstream through its own Quaternary Alluvial Sediments. The landscape is largely shaped by landslides resulting from seismic shaking originating at the San Andreas Fault, 1 mile east of the MHC watershed (Collins and Ketcham 2001).

Vegetation in the watershed varies with geology and elevation. Bishop pine forest dominates upland, north coast chaparral below 560 ft, and red alder in the valley down to Muddy Hollow Reservoir. The undergrowth is an often-dense thicket of mostly blackberry and sword fern. Riparian vegetation is bishop pine along the upper reaches, red alders and some willows along the middle, and a wide alder forest along the lower reach to Muddy Hollow Reservoir. MHC flows through tidal marsh from the reservoir to Estero de Limantour. The bishop pine and underbrush species are adapted to fire. When the surface biomass is completely burned, the root networks stay alive and add to the cohesion of the soil (Collins and Ketcham 2001).

Mt. Vision Fire

The Vision Fire of October 1995 began when smoldering embers from an illegal fire at a campground atop Mt. Vision ignited a four-day conflagration. From October 3 to October 6, the combination of high winds and low humidity allowed the fire to spread rapidly and eventually consume almost 13,000 acres of forest at the center of Point Reyes National Seashore included virtually all of the MHC watershed.

Previous Study

Collins and Ketcham completed a river survey of MHC documenting the changes in the watershed and river geomorphology for the two years following the fire. The middle watershed did not significantly change until the second post-fire year, 1996-1997, when large amounts of woody debris fell into the channel, resulting in bed erosion and incision. This increased sediment load and deposition to the lower reach, which responded by forming an alluvial fan and braided channel system. The middle reach became entrenched due to high flows in 1996.

Collins and Ketcham found sediment deposition in the lower reach was 2.7 times greater in the second year than the first post-fire year. They estimated the minimum average sediment load during these two years was 2,626 tons/sq mile/year. They hypothesized that as the sediment load and flow decreased the lower reach would return to a single channel and an extensive alder forest would grow. They predicted that the channel geometry of the middle reach would continue to adjust to high shear stresses during flood flows.

Our study uses similar methods and compares results with the previous study to evaluate changes in the creek since the fire. Combined with the Collins and Ketcham study, this report will form the foundation for a complete fire-response study that should be continued as the MHC watershed rebounds from the Vision Fire. The data collected for this report will supply further base-line data for river cross-sections, vegetation observations, and photograph records that can be compared to and built upon by future studies.

Methods

For the purpose of this study, the creek was divided into the middle reach and the lower reach, corresponding to reaches defined by Collins and Ketcham (Figure 1). The middle reach is the single channel from the confluence of the east and west upper reaches to the alluvial fan. The lower reach spreads into the alluvial fan of the creek and continues to the Muddy Hollow Reservoir and on to the Pacific Ocean.

The study initiated by Collins and Ketcham was halted in 1997 due to the inaccessibility of MHC two years after the fire. Dense development of vegetation along the creek prevented access to measured cross sections, existing flow gauges, and the riverbed area (L. Collins, Watershed Sciences, Berkeley, CA, personal communication, October 2004). Inaccessibility continues to be a problem.

River cross-section surveys

In order to establish an ongoing monitoring program at the middle reach of the creek, Collins and Ketcham placed permanent markers to delineate cross-sections at longitudinal intervals no greater than ten meters. Not all of these marked cross-sections were previously surveyed. Those that were originally surveyed are now in locations that are not accessible for proper surveys due to the dense vegetation surrounding the creek. The National Seashore does not allow researchers to clear vegetation.

Using a level and rod, we measured three previously marked but unsurveyed cross-sections for our study (See figure 2). Our three locations were chosen where current vegetation indicated accessibility in the future is likely. Brush along the banks in these locations was dead and no new growth was established. To augment the survey elevation data, we took photographs of the cross-sections and the general study area. These photographs reveal changes in vegetation and geomorphology.

Photograph comparison

Using both ground and aerial photographs, we compared vegetation, geomorphology, and sedimentation over the Muddy Hollow Creek study area including the riverbed, floodplain, and watershed. Many of the changes occurring in the alluvial fan can easily be viewed and photographed from Limantour Road. The Limantour vantage point (indicated in Figure 6) was also used by Collins and Ketcham. The easy access will allow future photography from the same location.

Results

Geomorphology

For the three cross-section locations labeled on Figure 3, we measured and plotted cross sections. Cross-section 2 and Cross-section 3 do not extend across the river due to dense vegetation, animal habitat, and potentially dangerous bank erosion conditions. Measurements for these cross-sections begin from the west bank marker and extend as far toward the east bank marker as practicable. Complete survey data is available in the attached appendix.

Photographs of the alluvial fan were taken from above the valley on Limantour Road and down in the valley. These photographs (Figure 7) along with aerial photographs (Figure 6) can be compared to historical photos to discern changes in the creek and floodplain.

Discussion

Geomorphology

We cannot compare our thalweg depth to the measurements provided in the 1997 longitudinal survey by Collins and Ketcham because a common benchmark could not be established. However, the change in elevation from our cross sections 2 and 3 downstream to cross section 1 (-2.2 ft and -3 ft, respectively) are similar to the change in elevation observed in 1997, +1.6 ft. This shows that there is no localized incision or sedimentation at the location of the cross-sections. In addition to the measured cross-sections, we are able to draw some conclusion from a photo comparison of our cross section 1 location, Collins and Ketcham's second gage site. A photo from before 1999 shows the same view as one taken in 2004 (Figure 4). The 2004 sediment level on the gage (not visible in these photos) is within 2 cm of the 1999 level. No significant changes in channel geometry are apparent. We believe that there is no significant change in the channel geometry of the middle reach since 1997.

While we do not believe there is significant erosion in the middle reach, we observed loose soils and little vegetation on the actual banks. Large woody debris continues to decompose along the banks and fall into the creek bed. While we expect that the large woody debris in the bed would hold back some sediment, as the debris decomposes erosion could continue.

At the lower reach, the creek is beginning to incise the loose, sandy sediment deposits. Aerial photographs and site visits show that immediately following the fire, the creek formed a braided channel as it approached the reservoir (Figure 6). We observed that the creek within the alluvial fan is beginning to form more defined channels with less braiding at the head of the fan. The creek has eroded through several visible layers of deposited sediment and pools are beginning to form in many locations. Aerial photographs and photographs taken from Limantour Road confirm the change in stream characteristics (Figure 7).

The incising river in the lower reach enforces our assertion that there is less erosion occurring in the middle reach than at the time of Collins and Ketcham 2001.

Vegetation

We observed the most prominent changes in vegetation at the alluvial fan of Muddy Hollow Creek. For years following the Vision Fire, the creek deposited an elevated sediment load at the fan. Collins and Ketcham documented 8,897 cubic yards of fresh sediment deposited in 1996 and 1997 above dark, hydrophobic ash that was formed during the fire. The majority of the sediment was sand size and granitic in origin, very little silt was observed. Figure 5 shows a time series of the alluvial fan. The alluvial fan from 1995 to 1997 was mostly bare sand (Collins and Ketcham 2001), but now supports a young alder forest.

Alder forests are also growing along the riparian corridor of the middle reach of MHC since the previous study. In the floodplain of the middle reach, the new alder forest growth along the river has caused many of the blackberry bushes, grasses, and other short shrubs to die off. Many of the dead alder trees that fell over the creek after the fire are continuing to decompose.

Conclusions

Muddy Hollow Creek is continuing to transition from a fire-consumed state. In the first year following the fire, stream flow increased due to hydrophobic soils and decreased vegetation. An alluvial fan formed in the lower reach of the creek which became a braided channel system. In the second year, elevated stream flows continued and new riparian vegetation began to grow. The middle reach of the creek incised after large woody debris fell into much of the stream bed. Sediment deposition in the lower reach elevated to 2.7 times that of the first year and the alluvial fan spread over the majority of the valley floor (Collins and Ketcham 2001).

Since 1997 the channel geometry of the middle reach has not changed significantly. Woody debris inside the channel is continuing to decompose and new alder growth is recreating a dense canopy over the creek. An alder forest has developed on the alluvial fan and the lower reach is beginning to abandon its braided form for a single channel.

While the original cross-section sites remain inaccessible, future studies will eventually be able to use these data as well as the previous data to compare continuing changes in the river geomorphology.

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