

Pre-1989 Landslides and Landslide Hazard Mapping In the Summit Ridge Area of the Santa Cruz Mountains

1. Landslides Caused by Previous Earthquakes

Landslides are known to have occurred in the Santa Cruz Mountains during both the October 8, 1865, earthquake (M 6.5) on the San Andreas fault and the October 21, 1868, earthquake (M 7.0) on the Hayward fault. However, the landslides in these events were not well documented, and the available historical information is fragmentary (Youd and Hoose, 1978; Marshall, 1990). Among the fragmentary accounts from the 1865 earthquake are reports of landslides from a few scattered localities including the Mountain Charlie area (Youd and Hoose, 1978; Marshall, 1990). Information from the 1868 earthquake is even more fragmentary, with known reports of landslides in the Santa Cruz Mountains only at Eagle Glen and Pescadero (Youd and Hoose, 1978; Marshall, 1990).

Documentation of landslides caused by the much larger April 18, 1906, San Francisco earthquake (M 8.3), while not complete, was substantially more extensive owing to one of the world's first scientific post-earthquake investigations (Lawson and others, 1908) as well as to information in many other reports, books, and newspaper articles. The 1906 earthquake caused thousands of landslides through and area of approximately 12,000 square miles (Keefer, 1984), including all of the Santa Cruz Mountains. In particular, the earthquake reactivated many pre-existing landslides (Lawson and others, 1908, v. 1, p. 385).

The severity of landsliding in and around the Summit Ridge area during the 1906 earthquake was described in general terms in an article in the Santa Cruz Morning Sentinel of May 1, 1906, (p. 2) as follows:

"From all reports, the higher altitudes of the Santa Cruz Mountains all the way from beyond Saratoga to Loma Prieta, on both slopes, appear to have been more seriously disturbed than many localities in the valleys and foothills. In places the roads are or were impassable, not only on account of great avalanches of stones and earth, but of wide deep cracks in the earth where the ground was rent asunder."

More specific and detailed descriptions of the many reported ground cracks and landslides caused by the 1906 earthquake in and around the Summit Ridge area are given in table 2.1. Most locations given in the original reports were not precise enough to identify the specific hillsides where landslides occurred, and the reports were almost certainly incomplete, because landslides were not mapped in a systematic or comprehensive manner. However, even the incomplete and imprecise information available from the 1906 earthquake indicated that landslides occurred in many parts of the Summit Ridge area, including Summit Ridge, Skyland

Ridge, the Morrell, Burrell, and Laurel areas, and along Old San Jose and Redwood Lodge roads. The reports indicate that several of these landslides were relatively large and that, in several localities, many landslides occurred. During the earthquake, two large, fast-moving avalanches of rock and soil killed 10 people near the Summit Ridge area; nine people were killed at Olive Springs, just south of the study area boundary, and one person was killed at Grizzly Rock, 6 miles northwest of the study area. The rock-and-soil avalanche at Olive Springs was reported to have been approximately 1,500 feet long, 400 feet wide, and 100 feet deep and the avalanche at Grizzly Rock approximately 1,200 feet long, 240 feet wide, and 300 feet deep (table 2.1).

2. Landslides Associated with Rainfall

Table 2.1 -- Landslides and ground cracks in and around the Summit Ridge area produced by the April 18, 1906, earthquake (M 8.3) (modified from Youd and Hoose, 1978, table 6, and Marshall, 1990).

Location	Description and Original Reference
Alma	<p>A landslide dammed Alma creek creating danger of flooding. (Santa Cruz Evening Sentinel, April 19, 1906, p.5).</p> <p>"The ground around the [devastated Tevis] house and in the hills above, was opened in hundreds of places in fissures of from a few inches to three feet in width. The depth of these is not apparent as the ground is broken in a zigzag manner." (Santa Cruz Morning Sentinel, May 1, 1906, p. 2)</p> <p>"On the ranch of Dr. Tevis [presently the site of Alma College], about a mile from Alma Station, where the land is rolling and wooded, the ground was fissured and the bottom of an artificial lake was upheaved.... The cracks and fissures, of which there are many, run mostly north and south, and vary in length up to 100 feet, and in width from 0.5 inch or less to 20 inches. While a good many of the openings were parallel to the slopes and were caused by the ground starting to slide, others crost the roads and could be traced some distance up the banks. A board fence was splintered where it crost a fissure. The upheaval of the lake was caused by a closing together of sides, shown by the heaving up of parts of the retaining dam at the lower end of the lake. The rise of the bottom is roughly 10 feet." (Lawson and others, 1908, p. 275)</p>
Eva	<p>A 10-acre slide dammed the creek at Eva station until the water crossed the railroad tracks following a new raised channel. (Santa Cruz Morning Sentinel, April 26, 1906, p. 8)</p> <p>A "huge earth slide dammed the creek at Eva station, creating a natural lake that blocked all [railroad] travel...for months." It took until December to remove the slide and lake. (Young, 1979, p. 29)</p>
Alma to Wrights	<p>The railroad between Alma and Wrights was impassable due to several landslides and boulders on the tracks. (Santa Cruz Morning Sentinel, April 26, 1906, p. 8)</p> <p>A landslide dammed Los Gatos Creek at the News Letter ranch, forming a lake with depth ranging from 50 to 100 feet. (Santa Cruz Morning Sentinel, May 1, 1906, p. 2)</p>

Patchin to Wrights	<p>"On the ridge road, about 5 miles northwest of Wright Station, the fault again shows slightly in a few 2-inch cracks.... Going down the slope from here to Wright, the cracks rapidly become larger. ...At Patchin, 3 miles west of Wright Station, there are fissures over a foot wide trending mainly in the direct line of the fault (S. 33degree E.). Several stretches of numerous small cracks alternating with a few long continuous fissures, mark the course from Patchin to Wright Station." (Lawson and others, 1908, p. 109-110)</p> <p>"Just north of Wright's Station, on the west bank of Los Gatos Creek, there was a landslide 0.5 mile wide which had slid into the creek and dammed it. The top of this slide was near the Summit school-house and was close to the main fault-line." (Lawson and others, 1098, p. 276)</p> <p>"The main fault fracture is about 500 feet northeast of the [Summit] hotel, and a secondary crack close to it had a downthrow of from 5 to 7 feet on the north or downhill side. The crack was about 4 feet downhill from its original position toward the northeast." Just below the Summit school-house was the headscarp of the landslide that dammed Los Gatos Creek near Wright Station. (Lawson and others, 1908, p. 275-276)</p> <p>"At Freely's place, 4 or 5 miles north of Morrell's some 15 acres of woodland have slid into Los Gatos Creek, making a large pond. There are many other slides in the neighborhood and many broken trees." (Lawson and others, 1908, p. 278)</p> <p>"Into this [Los Gatos] creek, from the Freely ranch, some ten acres of land was thrown in a great landslide. At the head of the creek is the long tunnel which cuts under the saddle, from Wright's to Laurel." (Jordan, 1907, p. 27)</p> <p>"Landslides were abundant, especially in the Santa Cruz Mountains, where the topography is more rugged. One slide, a few miles from Wright's Station, involved eight to ten acres of ground." (Carey, 1906, p. 297)</p>
Wright's	<p>"Large fissures and ridges" formed in the ground at Wrights. (Santa Cruz Evening Sentinel, April 21, 1906, p. 2)</p>
Wright's to Laurel	<p>The Wrights to Laurel railroad tunnel collapsed in the earthquake just hours before the planned inaugural run of the first standard gauge train along this previously narrow gauge line. Where the tunnel crosses the summit it was offset laterally five feet. Almost all other railroad tunnels in the Santa Cruz Mountains suffered some collapse or were blocked by slides at their entrances. (Payne, 1978, p. 49)</p> <p>The Wrights to Laurel railroad tunnel cracked in middle and settled several inches out of line. (Young, 1979, p. 38-39)</p> <p>"The tunnel floors have raised as much as three to four feet in places...." (Santa Cruz Morning Sentinel, April 26, 1906, p. 8)</p>
Laurel to Glenwood	<p>Minor slides blocked the Glenwood-Laurel tunnel. (Young, 1979, p. 39-39)</p> <p>Four hundred feet of tunnel #3 between Laurel and Glenwood caved-in. (Santa Cruz Evening Sentinel, April 19, 1906, p. 5)</p>

Morrell Ranch	<p>"The Morrell ranch is located 1 mile south of Wright's Station.... The house itself was built exactly upon a fissure, which opened up under the house at the time of the earthquake. The house was completely wrecked, being torn in two pieces and thrown from its foundation.... There was an apparent downthrow upon the northeast side of the fault, as seen in the orchard; but under the house the vertical movement was not so apparent. ...The fence and road near the house were crost by the fault and showed an offset which indicated a relative movement of the southwest side toward the southeast. ...The "splintering" of the main fracture raised a long, low ridge across which a creek had been forced to cut its way thru a vertical distance of 1.5 feet to get down to its original level." (Lawson and others, 1908, p. 276-277)</p> <p>"The earthquake crack past thru [the Morrell] ranch, a branch of it going under the house. The main body of the house was thrown to the east, away from the crack, the ground there slumping several feet and the house being almost totally wrecked. All thru the orchard the rows of trees are shifted about 6 feet, those on the east side being farther north, and the east side, which is downhill, seems to have fallen. The crack is largely open and in one place is filled with water. This should be attributed to slumping. A little farther on, the crack passes thru a grassy hill on which there is no slumping. The Morrells say that this hill has been raised. What appears to be the fact is that the east side of the hill overrides the other. The whole top of the hill is more or less cracked for a width of about 10 feet. The east side is a little higher than the west side, and it looks as though the hill had been shoved together and raised, the east overriding. About 1 mile beyond Morrell's house, at the end of the ranch, there is a blacksmith shop, and the road is crost by the crack. Here there is a break of 3 or 4 feet like a waterfall, the east side being the lower; but this is part, I take it, of the general slumping of the east side of the crack where it stands near the ravine above Wright. Morrell's place is right over the Wright tunnel, the tunnel and the rocks near by being finely broken rock and very much subject to slides and other breaks." (Lawson and others, 1908, 277-278)</p>
Burrell	<p>"In the Burrell district there is one fissure in the hillside fully 3 feet wide. This crossed the road and tumbled Ingraham's store building into the gulch." (Santa Cruz Morning Sentinel, April 24, 1906, p. 7)</p> <p>"Near the Burrell school-house, 1.5 miles southeast of Wright Station, a crack extends across the road by a blacksmith shop and shows a downthrow of four feet on the northeast." (Lawson and others, 1908, p. 276)</p>
Burrell [Laurel] Creek	<p>"Gulches appear to have been contracted as the bridges crossing them show that they were squeezed. The banks of Burrell Creek appear to have approached each other, so that the creek has become very much narrowed. Water pipes were broken and twisted, and filled with dirt." (Lawson and others, 1908, p. 276)</p>
Highland	<p>"Half a mile to the northwest of the [Beecher] house [on Loma Prieta Avenue], a fissure 2 feet wide appeared.... The fissure runs from north to south, and the earth was piled up on the west side from 2 to 4 feet high across the road. On Highland, a mile to the west, a fissure 5 feet was opened at an elevation of 2,500 feet." (Lawson and others, 1908, p. 276)</p>
Skyland	<p>"Large landslides occurred in the neighborhood." (Lawson and others, 1908, p. 278)</p>

	<p>"The road between the King and Crane places has slid into the orchard below." (Santa Cruz Evening Sentinel, April 21, 1906, p. 4)</p> <p>"There seems to have been a narrow strip, about two miles wide, east of Skyland, with Skyland as the center, where hardly a building remains standing or unbroken. ..."One section of road of about 3 miles long is hardly without a crack.... At one place in the road it has been lifted fully 5 feet." The road was still impassable after three days of heavy work by a crew of 6 men. (Santa Cruz Morning Sentinel, April 24, 1906, p. 7)</p> <p>"...the cracks run up over the ridge just west of Skyland. Large fissures show in the orchards and fields on the eastern side of the ridge, but are not so evident on the western slope. Here instead, great landslides occurred, and redwoods were snapped off or uprooted." (Lawson and others, 1908, p. 110)</p> <p>"The slides which obliterated Fern Gulch at Skyland...lie to the west of the crack [fault]." (Lawson and others, 1908, p. 278)</p> <p>"On the western slopes of the ridge just west of Skyland, several earth-avalanches were caused by the shock; and great slides of a similar character occurred on both sides of Aptos Creek for 0.75 mile. Besides these, there were many smaller earth-avalanches in many parts of the Santa Cruz Mountains which cannot be enumerated." (Lawson and others, 1908, p. 389-390)</p>
"About Four Miles South of Wright Station" [probably near Laurel township]	"The ridge...was full of cracks, ranging up to 2 and 3 feet in width, and in length from a few rods to 0.25 mile, all trending west of north to northwest. ...The canyon south of use was filled with landslides. In this canyon the stratification of the rocks is plainly shown. The strike is northwest-southeast and the dip is almost vertical. Cold water was flowing from some of the cracks." (Lawson and others, 1908, p. 278)
San Jose-Soquel Road	San Jose-Soquel road suffered extensive damage in the earthquake, but was reopened by July 4, 1906. (Payne, 1978, p. 17)
Redwood Lodge Road	The earthquake "severely damaged Redwood Lodge Road and workmen took until June, 1906 to complete repairs." (Payne, 1978, p. 17)
Upper Soquel Creek	A newspaper article of May 7, 1906 reported an eyewitness story that the headwaters of Soquel Creek were dammed by two landslides, forming a pond 100 feet deep. The upper Soquel Creek basin was reported ravaged by fallen trees and boulders as well as "great fissures and landslides. ...The roads were gone and in their stead were chaotic masses of debris from the hillsides." An article of May 9 corrected the account after the site was visited by another eyewitness. This second account claims the damming of the creek resulted not from landslides but from an upward vertical displacement of the creek bed of from 5 to 30 feet in places. The pond averaged 15 feet in depth not exceeding 20 feet. Many fissures in the ground near Soquel Creek were "now largely filled in." (Santa Cruz Evening Sentinel, May 7, 1906, p. 1, and May 9, 1906, p. 1)
Hinckley Creek (Olive Springs)	<p>"The mountains are said to have come together and 17 lives...lost." [9 were actually killed.] (Santa Cruz Evening Sentinel, April 18, 1906, p. 1, and April 19, 1906, p. 7)</p> <p>With the first severe shock of the earthquake, a landslide 500 feet wide, extending</p>

up to the ridgetop, descended with "extraordinary speed," burying the Loma Prieta lumber mill under a mass of rock and trees of "about 100 feet in depth at the worst places and gradually diminishing at the edges of 25 feet." Nine men were buried instantly while others, only several hundred feet away, were spared. "The mountainside where the land fell was swept bare of vegetation. Massive redwoods and pines were jammed on top of the mill in the gulch below. ...The landslide filled the water course. The stream was dammed and the water rose to a depth of sixty feet in the gulch. A pump was set to working and the water is now being used to wash away the earth from the machinery." Hundreds were involved in a massive digging effort in the following week, but only three bodies had been discovered by five days later. [More than a year passed before the last body was finally removed from the debris.] (Santa Cruz Morning Sentinel, April 26, 1906, p. 1)

The mill was buried under 60 feet of earth and trees, whereas the nearby bunkhouse, where nine men were sleeping, was buried under 10 to 15 feet of debris. (Patten, 1969, p. 79) A second slide occurred during an aftershock at 11 p.m., April 19 interfering with rescue efforts. (Santa Cruz Evening Sentinel, April 21, 1906, p. 2)

"Near Olive Springs, 12 miles north of Santa Cruz, an earth-avalanche demolished Loma Prieta Mill and killed several men." (Lawson and others, 1908, p. 389)

"At Santa Cruz the inhabitants reported that near Olive Springs, 12 miles north of Santa Cruz, a landslide demolished Loma Prieta Mill and killed 9 men." (Lawson and others, 1908, p. 271) "...the [fault] crack goes into Hinckley's Gulch, in which the Loma Prieta Mills are situated, and which are buried under the slides." (Lawson and others, 1908, p. 278)

"On the northern side of Bridge Creek Canyon there are typical cracks from 1 to 8 inches wide, and here also occurred a great landslide which buried the Loma Prieta Mill." (Lawson and others, 1908, p. 110)

"Wreck of Loma Prieta Sawmill, Hinckley's Gulch, Santa Cruz County." (Jordan, 1907, p. 30) [Picture caption]

"Site of Loma Prieta Sawmill, covered to a depth of 125 feet." (Jordan, 1907, p. 31) [Picture caption]

"Loma Prieta Lumber Company's Mill. The mill, boarding house and other building of the plant were situated in a gulch, and were overwhelmed by a portion of the mountain--1500 feet long, 400 feet wide and 100 feet deep which slid down upon them. The mill and everything in the gulch were forced up the opposite slope of the mountain and there buried to a depth of one hundred feet. Pine and redwood trees 100 feet high came down with the slide and are now standing over the mill site as though they had grown there. Nine men were killed." (Salinas Daily Index, April 25, 1906, p. 3)

"LOMA PRIETA CO'S LOSS. When the earthquake occurred yesterday morning

	<p>it caused a large mountain of earth to slide into the canyon and completely covering the new mill. Continuing its course up the mountain on the other side it covered what is known as the bunk house and buried ten men, who were asleep at the time." (Salinas Daily Index, April 19, 1906, p. 3)</p>
<p>Castle Rock Ridge</p>	<p>"A small landslide had moved across the road [8 miles north of Boulder Creek] which 20 men spent one and a half days clearing away. ...Up the road to the summit of Castle Rock Ridge no slides or cracks were observed." (Lawson and others, 1908, p. 268)</p>
<p>Deer Creek (Grizzly Rock--northeast of Boulder Creek)</p>	<p>An extensive landslide descending from the eastern side of the valley buried the Deer Creek shingle mill, houses, trees, etc. Two people were killed. The site of the mill was estimated to be under 50 to 100 feet of earth. The slide apparently had two lobes, one moving to the west and the other to the east. A witness watched as large redwoods on the slide mass performed "all kinds of acrobatic feats." "Where formerly there was high hills and wooded lawns nothing now remains but a wide level stretch over a mile long and covered with the protruding tops of trees." (Santa Cruz Evening Sentinel, April 19, 1906, p. 4)</p> <p>An article reprinted from the "Mountain Echo" said that the crest of a spur ridge off of the main mountain summit northeast of Deer Creek failed and "swept in a semi-circular pathway of destruction for three-fourths of a mile toward Deer Creek. A fine redwood forest in its pathway, and the property of Isaiah Hartman of this place, was swept down like grain before the reaper. ...It was many minutes after the heavy series of earthquake shocks...that the avalanche was discovered to be approaching with the mighty roar of crashing timber and grinding rocks. When first seen it was over a quarter of a mile away across a flat country and no one dreamed it could reach the mill. It however, swept onward in a bending course with a solid wall of earth and redwood trees fifty of sixty feet high.... The mill cabins were crushed like eggshells and buried in the debris while the mill itself disappeared under the moving wall." One person was killed at the mill, while another was killed at a different site on the other side of a ridge one-half mile to the east. (Santa Cruz Evening Sentinel, April 23, 1906, p. 1)</p> <p>In a report of a visit to the site of the Deer Creek slide two months later, the base of the slide was encountered a half mile above the Santa Clara Lumber Co. mill near the site of a new shingle mill. An eyewitness to the slide said it took less than a minute for the slide to move from its origin 400 feet above and half a mile distant down onto the old shingle mill. The slide descended a winding gulch carrying a huge mass of rock, soil and large trees. (Santa Cruz Evening Sentinel, June 21, 1906, p. 5)</p> <p>"On Deer Creek, in the Santa Cruz Mountains, an extensive earth-avalanche started near Grizzly Rock and moved westward down a steep, narrow canyon for about 0.25 mile. (Plates 124D and 125A.) It then changed its course thru an angle of about 60degree as it entered a wider canyon of lower grade, and following this for another 0.25 mile, finally stopt at the Hoffmann Shingle Mill, which was wrecked. A fine growth of redwood, some 200 feet in height, was mowed down, and covered to the extent of 10 acres or more with from 30 to 60 feet of debris. The trees were from 3 to 10 feet in diameter. The main canyon was filled with earth and rock for an average width of 80 yards and a length of 400 yards. The entire area of the slide was about 25 acres. The difference in altitude between the</p>

	<p>point where the slide started and the shingle mill where it stopt, is 500 feet. According to Mr. G. A. Waring, the slide material has a depth of 300 feet and is composed of soil, clay, and shale. Mr. E. P. Carey, who examined and photographed this interesting earth-avalanche, states that it originated in rock that broke away in pieces from the steeply inclined slope at the head of the gulch, leaving a large theater-like space, the bare, light-colored rock walls of which were in sharp contrast with the surrounding green vegetation. The movement was faster in the center or deepest part of the gorge than on the margins. The rock was in general piled up higher along both sides than in the center, and many pieces became entangled in the standing or uprooted trees. A steep-walled tributary to the southeast of the main gulch supplied rock material to the main avalanche, and the 2 streams joined much as confluent glaciers do. The material involved in the avalanche showed every gradation from powder to angular pieces 30 feet or more in diameter. The surface was uneven throughout. Near the mill a man was killed by a tree that fell as the avalanche was advancing." (Lawson and others, 1908, p. 388)</p> <p>"On Deer Creek a large landslide started from near Grizzly Rock and slid westward, but changed its direction 60degree or more farther down toward the creek. The mill in the creek bottom below the slide was partly buried, and one man was killed. It is 500 feet from the mill in the gulch to the top, at the point where the slide started. The slide covered about 25 acres of ground, and destroyed a lot of virgin timber from 3 to 10 feet in diameter. The slide materials, which is 300 feet deep, is composed of soil, clay, and shale." (Lawson and others, 1908, p. 267)</p>
<p>Bear Creek (NE of Boulder Creek)</p>	<p>"On Bear Creek... a smaller slide [than the Deer Creek slide] had moved a few hundred feet, buried a hut, and killed one man. According to reports of men in this region, only a minute elapsed after the beginning of the earthquake before the slide was over. Down in the valley no cracks or other evidence of disturbance could be seen." (Lawson and others, 1908, p. 267)</p>
<p>Cauley [Connely?] Gulch</p>	<p>"Mr. Carey also reports another earth-avalanche located on the Petty ranch, about 4 miles southeast of the one just described [Deer Creek landslide]. Here a huge rock mass, which embraces an area of about 12 acres at the headwaters of Cauley Gulch, broke away from a ledge and dropt, leaving a vertical scarp of 40 feet or more. The rock mass in this case was not shattered. It practically maintained its integrity. The narrow gulch below was unfavorable for free downward movement. As the block readjusted itself, its upper surface became nearly level, but was lower at the foot of the scarp than at its outer edge, thus indicating that it had suffered rotation." (Lawson and others, 1908, p. 388)</p>
<p>Grizzly Rock</p>	<p>"The whole ridge west of the reservoirs [about 2 miles south of Congress Springs] was severely shaken, however, for cracks 4 or 5 inches wide opened near Grizzly Rock and several large slides occurred in its neighborhood. One water-pipe running north and south on the Beatty place was broken, while one trending east and west was unhurt. No cracks were found crossing the ridge between Grizzly Rock and White Rock. The cracks were next found on the road about a mile east of B.M. 2135 of the U.S. Geological Survey, but they do not show in the vineyard to the southeast." (Lawson and others, 1908, p. 109)</p>

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