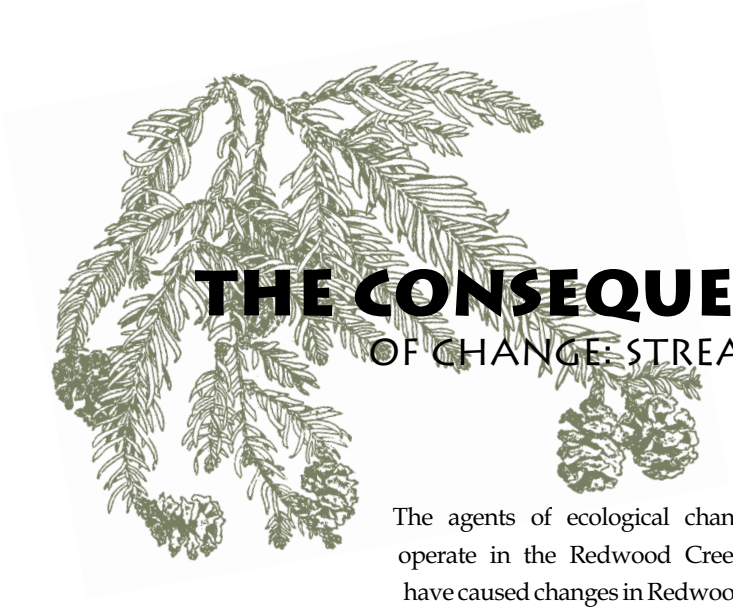


THE CONSEQUENCES
OF CHANGE: STREAM HABITAT

The agents of ecological change that operate in the Redwood Creek basin have caused changes in Redwood Creek channel morphology—the shape of the streambed—and the level of sediment in the streambed over time.

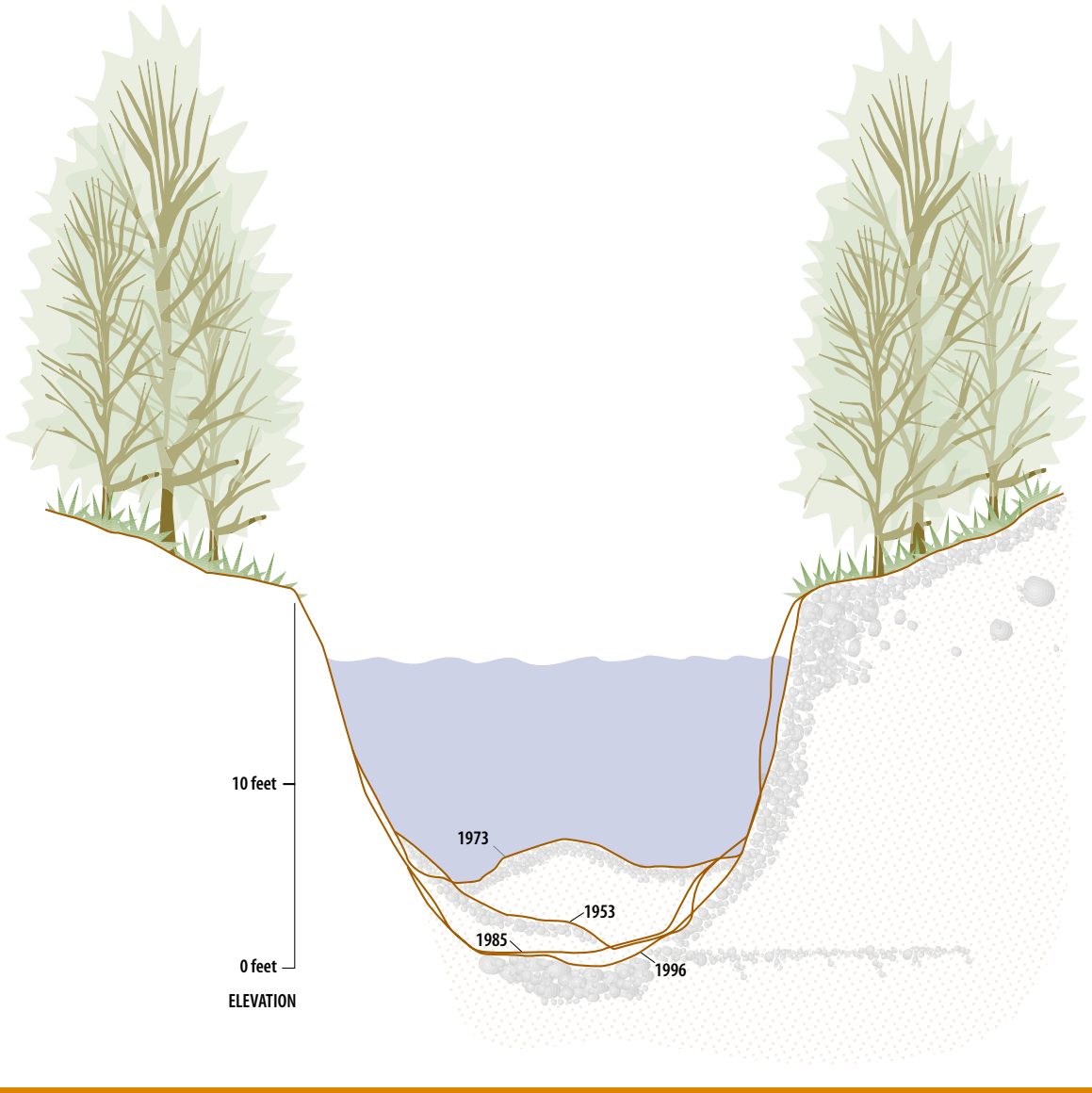
The Cycle of Channel Morphing

Upper Redwood Creek (above State Highway 299). The long-term record for the upper basin indicates that the streambed of Redwood Creek rose 10 feet—in some locations nearly 30 feet—between 1953 and 1973, and returned to its 1953 level by 1986.[148,149]

The lack of recent significant changes in the streambed suggests that conditions today are similar to pre-1953 conditions for much of the upper reach.[150] The large streambed particles, exposed bedrock, established riparian vegetation, and lack of flood debris present today indicate a very stable channel without much new sediment deposits.[151,152]

Middle Redwood Creek (State Highway 299 to Redwood National Park). The stream channel in the middle section of Redwood Creek has not changed significantly during the 1990s.[153] Apparently stable, this reach has likely joined the upper reach in returning to pre-aggradation conditions such as existed before 1953.[154,155]

Lower Redwood Creek (Redwood National Park to the Ocean). In 1985, a major channel constriction in the lower section of Redwood Creek between Copper Creek and the Tall Trees Grove caused some buildup and leveling above and erosion below the constriction.[156] By 1986, the reach was neither leveled above nor degraded downstream of the Tall Trees Grove.[157] More recently, about 8 inches of buildup was measured; this is a minor amount of change, given the drainage area above the reach.[158,159] Currently, the area shows short, braided reaches and secondary channels created by mid-channel gravel bars.[160] These are especially



Channel sediment elevations rise and fall with flood events.

Source: N. Varnum. 1984. Redwood National Park.

productive sites for rearing salmon and steelhead trout.[161]

Sedimentation and the Streambed Cycle

Redwood Creek was formed in a sediment-rich basin that experiences a constant, high level of erosion, punctuated by periodic dramatic sediment disturbances. Sediment commonly involves fine particles the size of clay, silt, and sand, but may include particles up to house-sized boulders.[165] Between 60-95 percent of the sediment entering Redwood Creek is fine sediment.[166,167,168,169] Once deposited in a stream, a house-sized boulder may never move, but a small, suspended particle may be transported all the way from a stream's source to its mouth in a matter of hours. The rate at which a sediment particle is transported by flowing water toward the sea depends upon its size; the smallest particle is capable of remaining suspended in still water for days or years. In Redwood Creek, suspended sediment—usually fine sediment of up to about one-tenth of an inch in diameter—is rapidly transported during high flow storms.[170]

The soft rocks that make up the streambed of Redwood Creek are themselves a vast supply of fine sediment. While rolling downstream, these rocks release fine sediment as they break down.[171,172] Together, these factors supply an abundant amount of nat-

CHANNEL MORPHOLOGY: IN A NUTSHELL

Streambed elevations changed along the entire length of the main stem of Redwood Creek between 1973 and 1988.[162] Overall, a large amount of channel deposits were moved, including the majority of sediment delivered from landslides occurring during the 1964 storm.[163] The relatively rapid return to pre-flood conditions was made possible by the force of water in the channel and the relatively small size of the sediment particles brought in by floods.[164]

ural sediment to the stream channel; but the story doesn't end there.

The rates at which sediments are being flushed out of Redwood Creek are among the highest in northern California streams, which have some of the highest sediment transport rates in the world.[173,174,175] These high erosion rates are caused by the active tectonic uplift, soft bedrock, and the climate that characterizes the North Coast region.[176,177,178]

The amount, composition, and distribution of sediment in Redwood Creek are forever increasing and decreasing as the volume and velocity of water rises and falls.[179] The moderate flows that occur a few days every year are responsible for transporting the bulk of the sediment in the stream over the long term.[180,181] At times, however, rare events transport large amounts of sediment from upstream sources to the downstream reaches of Redwood Creek, many times over the amount of sediment normally transported in an average year.[182,183,184,185] It is estimated that the amount of sediment transported downstream varies by as much as fifty times from year to year, depending on the intensity of local storms.[186]

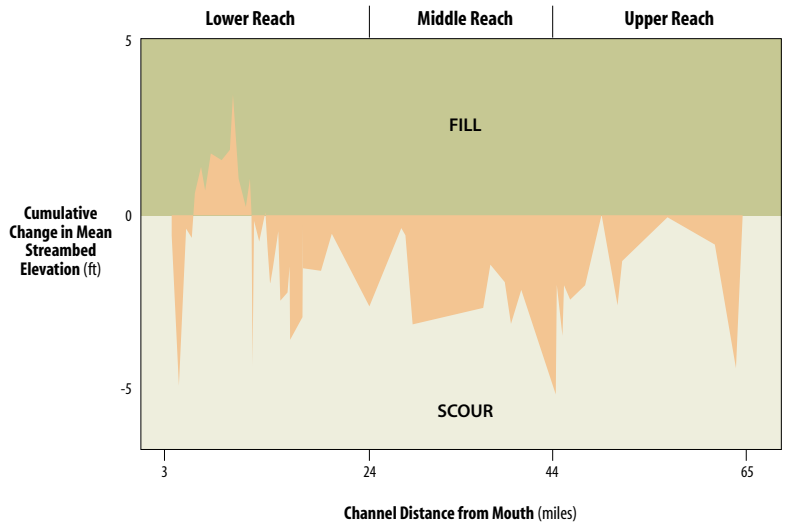
From rainfall and photo records, it appears that the amount and size mix of Redwood Creek sediment were changed by the storms of the late 1800s and returned to base levels by the 1920s and 1930s. Undoubtedly, the storms and land-use practices of the 1950s, 1960s, and 1970s again altered the sediment patterns. The particle-size distribution of streambed material in Redwood Creek prior to and during this period is unknown because no records were kept.[187] During August 1974, between the floods of 1972 and the flood of 1975, fine sediment composition was within the range of natural variability and varied slightly from the creek's headwaters to its mouth. The amount of fine sediment in gravels was highest (21.9 percent) in the upper reach, lowest (17.0 percent) in the middle reach, and intermediate (18.6 percent) in the lower reach.[188]

A significant discovery was made at Prairie Creek regarding fine sediment processes. It was found, during a 7-year period, that the fine sediment infiltrating into clean gravels reached a maximum amount, above which further deposition was hindered by a seal formed near the streambed surface.[189] In this case, the maximum amount of fine sediment was 25 percent of the streambed.[190] The formation of this surface seal appears to be inevitable once streambed sediment is moved by a storm flow.[191]

Extensive sampling of Redwood Creek's streambed in 1988 and 1989 showed the amount of fine sediment to be 9 to 25 percent of the subsurface streambed material, and sediment conditions were favorable for salmonid spawning.[192,193]

Indicators suggest that Redwood Creek's streambed has stabilized. There is a prevalence of well-winnowed gravel areas where surface layers of fine sediment have been removed by storm flows, and a high frequency of coarse particle sizes in reaches where sediment has been deposited or eroded.[194]

Over the past 25 years, the amount of fine sediment in Redwood Creek has become generally, though inconsistently, reduced, due in part to fewer intense storms than during previous periods of history.[195] Fine sediment has decreased at four sites, remained unchanged at one site, and increased at two sites.[196]



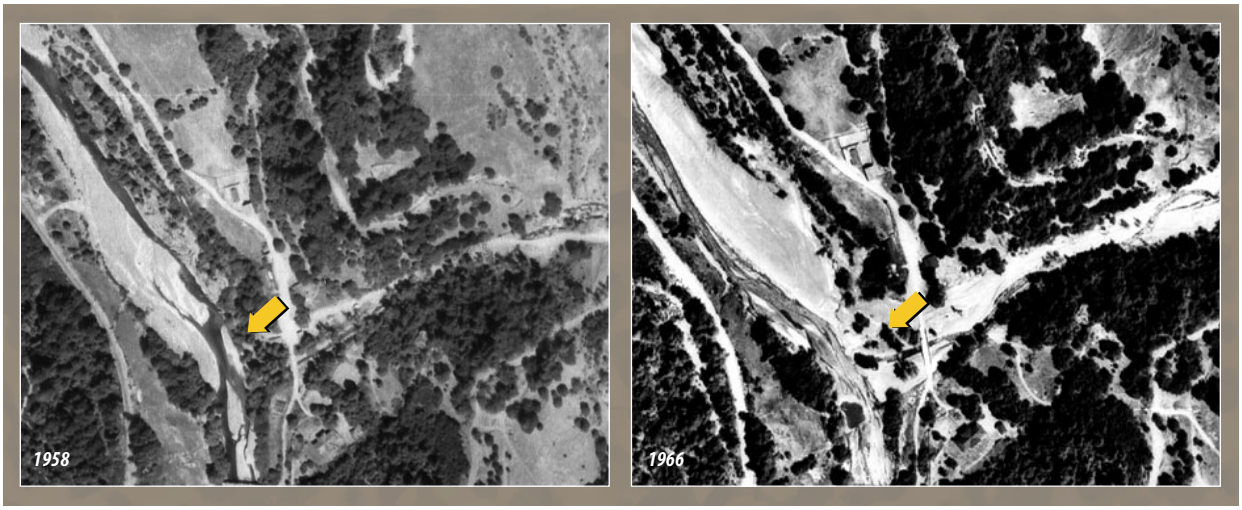
A sediment wave moved downstream between 1973 and 1988 during an inflooding.

Source: M.A. Madej and V. Ozaki. 1996. Earth Surface and Landforms 21:911-927.

SEDIMENTATION: IN A NUTSHELL

Cyclical sedimentation patterns in Redwood Creek are governed by local geology, tectonics, and climate, but normally shift very quickly. Most sediment is **deposited** during rare dramatic ecological events, but most sediment is **transported** by continual flows.[197,198,199] Primarily due to fewer intense storms in recent years, sediment levels in Redwood Creek have nearly returned to levels that preceded the 1953 to 1975 flooding period. It appears that Redwood Creek has cycled back, as it has in the past, from the changes brought on by the significant storms that began in the 1950s.

The periodic depositions of large amounts of sediment in Redwood Creek appear to be a result of natural events that have occurred periodically, and changes in channel morphology are inherently characteristic of this phenomenon.[200] Consequently, sedimentation is viewed by stream experts as an integral part of the cycle of any stream: it is necessary to forming and maintaining the natural system.[201,202] The input of new sediment appears to be essential to the process of replenishing the sediments that are continuously transported out of the stream system, and the natural rates at which sediments are being flushed out of Redwood Creek are among the highest in northern California—and the world!



These aerial photographs show changes in the channel shape and sedimentation levels from the flood of December 1964.