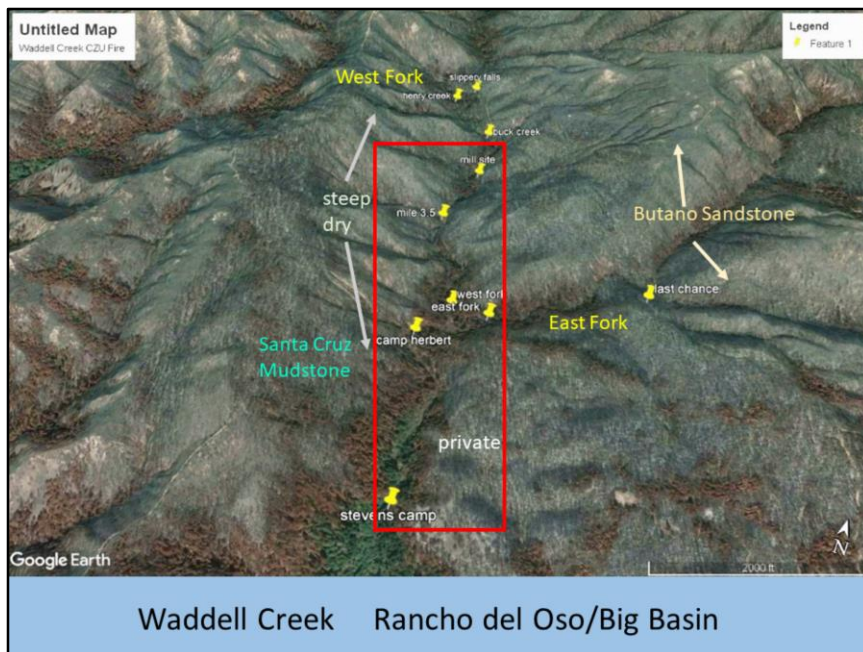


Impact of the CZU Fire on Stream Habitat in the Coastal Portions of Gazos and Waddell Creeks

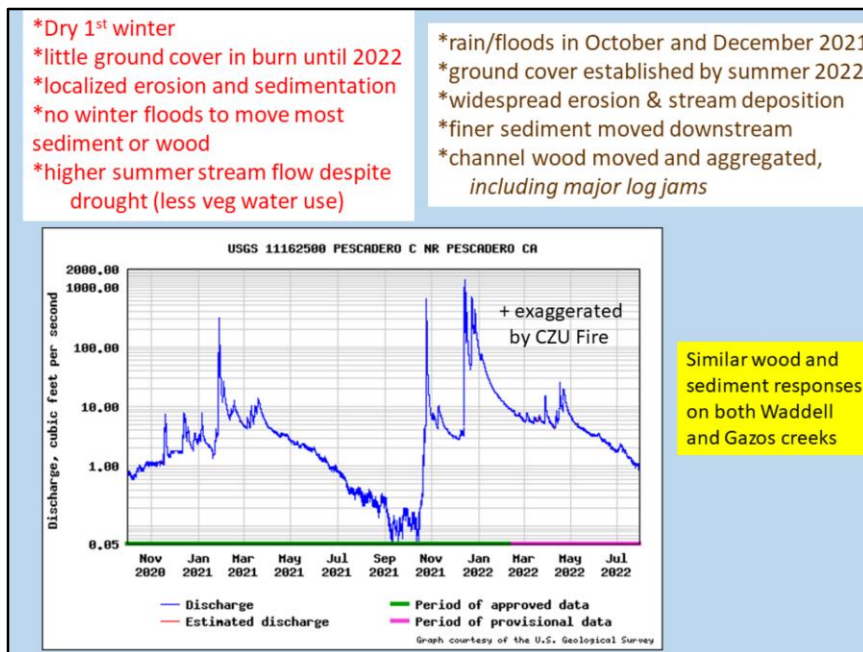
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Since 1992, I have annually sampled coho salmon (endangered) and steelhead (threatened) at the same index sites (yellow icons), including the same individual habitats, when possible, in Waddell, Gazos, and Scott creeks. The 2020 CZU Fire blocked fish sampling that fall, but allowed me to assess the impacts of the fire on Gazos and Waddell creeks in 2021 and 2022, and Scott Creek in 2022, and to also resume fish sampling on Gazos Creek in 2021 and on Waddell and Scott creeks in 2022.



This Google Earth photo of Waddell Creek immediately after the 2020 fire shows the severe upland fire damage in the coastal portion of the watershed, within the Rancho del Oso (RDO) portion of Big Basin State Park (the gray landscape, with dead or severely damaged standing or downed trees). In the most downstream portion (bottom) of the watershed the green forest along the stream extends to upstream of Stevens Camp, about 2.6 miles upstream of the ocean and about 0.8 miles upstream of the Twin Redwoods trailside camp in RDO. The orange forest in the photo shows moderate canopy burn, extending upstream to the lower east and west forks of Waddell. Farther upstream on the West Fork (along the Skyline to Sea Trail) and on the East Fork, most of the riparian forest was severely burned.

The red rectangle brackets a reach of six sample sites assessed in 2021, with three others also assessed in 2022 downstream of the direct fire effects. The west upland slope of Waddell and West Fork Waddell is steep and drier. Most of the watershed is composed of Santa Cruz Mudstone, which weathers easily to silt and fine gravel. Upstream on the East Fork, resistant Butano Sandstone produces cobbles and small boulders.



There is no flow gaging station on either Waddell or Gazos creeks, but the chart of 2021 and 2022 stream flow on Pescadero Creek (farther north) shows the general pattern through the first two winters after the fire.

The first winter after the fire was dry, with a single very modest storm at the end of January. Ground cover (shrubs and herbs) that had burned was not able to recover until after the wet winter of 2022. Forest loss and bare ground cover poorly protected the steep slopes, but winter runoff was limited in 2021. However, rain and runoff was substantial in October and December storms in 2021. With the bare slopes, the runoff was relatively higher in Gazos and Waddell creeks compared to Pescadero Creek which had little fire damage. The runoff in in October and December 2021 moved massive amounts of sediment and channel wood. Summer stream flow was significantly increased after the fire, because the loss of trees and of canopy on survivors reduced vegetation water use.

On both Gazos and Waddell creeks fine sediment was added to the streams in both years from slope erosion. In Waddell Creek steep west slope debris flows and slope erosion also added localized angular Santa Cruz Mudstone gravels to fill pools between miles 2.8 and the confluence of the east and west forks in 2021. In 2022 the effect was even more dramatic, with gravels and fines extensively filling pools throughout both streams.



Upstream to mile 2.75 on Waddell Creek the CZU Fire burned upslope but did not damage the riparian vegetation. At the upstream end of the reach, some trees were burned and toppled into the adjacent stream and some streamside alders were apparently cooked and killed (photo upper right). However, the channel was little affected in 2021.

The larger storms in October and December 2021 produced some localized slope erosion and debris flows (photo, lower left at Twin Redwoods Camp, mile 1.8). The high water also moved much old and new channel wood, including producing a major new high, tight, and wide log jam in a narrow, entrenched channel (like a cork in a bottle) at mile 0.65 (Photo, lower middle). That log jam is probably a substantial barrier to fish passage, and probably was in most of December 2021.

Pools in the reach suffered substantially with the December 2021 floods, with wood moved and sediment deposited, filling pools, which are important for over-winter survival of juvenile coho and steelhead. The photo on the lower right is typical, where old fallen alders were rinsed away, and the long, deep pool was mostly filled with sediment, except around a single large log.

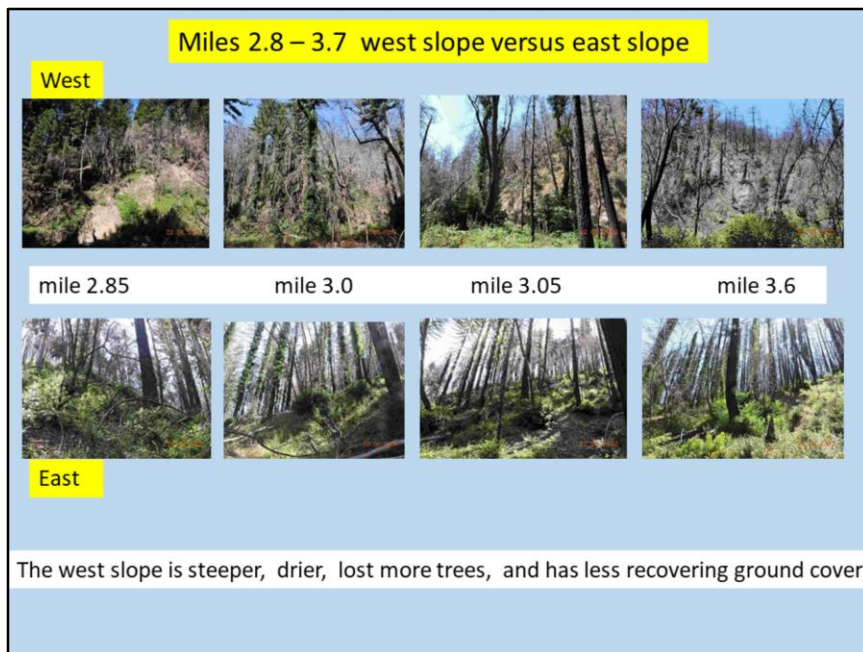
Miles 2.8 – to the confluence of the East and West Forks

2021 and 2022—fire burned to and across stream, alders killed, majority of canopy lost from surviving trees, water temperature increased, alder log jam, steep west slope erosion of fines and mudstone gravel, major filling of pools

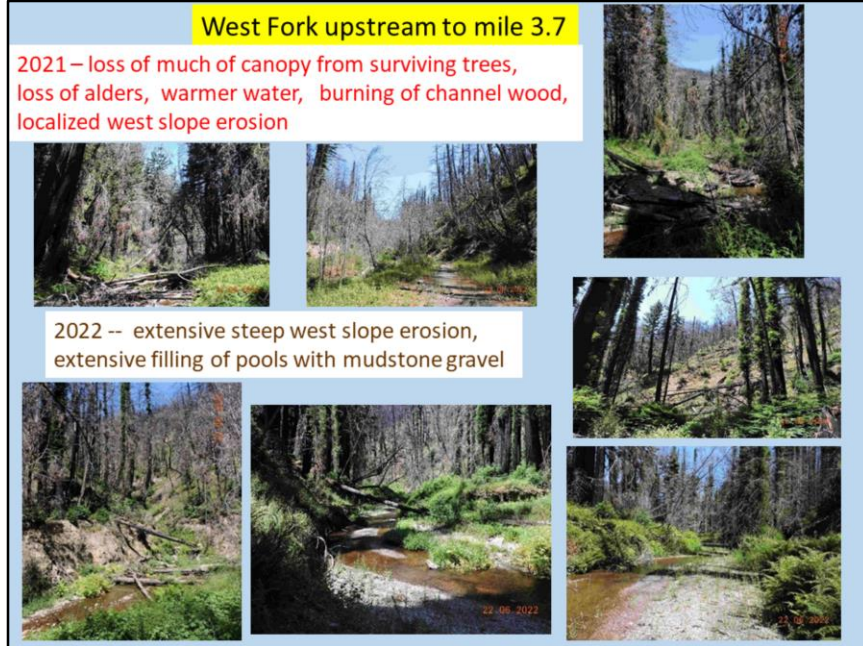


From mile 2.8 to the confluence of the forks the fire burned to and across the stream, killing most streamside alders and eliminating much of the channel shade (photos, upper left and upper and lower middle). Steep west slope erosion in the first winter (photos, upper middle and right), including a ridge top to stream debris flow at the forks (photo, upper right), dumped abundant small angular mudstone gravels (photo, lower left) into channel filling formerly deep pools (photo, upper left). Conditions were similar in 2022, because pools had already been filled and high flows added more sediment, rather than flushing it.

One debris flow in 2021 (at mile 2.85) also dumped several large trees into the channel, which caught some of the killed and transported alders, creating a large partly open log jam (photo, lower right). That log jam was tripled in length in December 2021 by storms that added many more dead alders to the jam.



The differences between the west slopes and east slopes above Waddell and West Fork Waddell were dramatic from miles 2.8-3.7. The west slope is much steeper and drier, and had more forest tree loss (including common Douglas firs). Ground cover recovery to protect the slope from erosion has been limited, despite more rain in the second winter. The east slope is less steep, and ground cover has substantially recovered. Most lower east slope redwoods had basal and trunk sprouting, and tanoaks had basal sprouts. The east slopes suffered relatively little erosion in the two years after the fire.



On the West Fork the fire burned across the stream killing the alders and removing most of the canopy of surviving trees (upper photos), including the riparian redwoods, which responded with branch and trunk epicormic sprouts. Streamside and lower slope bigleaf maples basally sprouted from their dead trunk by late summer 2021 (photo, upper middle) and will provide stream shading within about 10-15 years. The canopy loss resulted in increasing summer stream temperatures by 2-4 degrees C, but the effect was probably moderated by higher stream flow.

Channel wood that aided pool formation was also burned, including a major log jam from 1998 that was frequently a significant partial barrier to fish passage (photo, upper right). In 2021 there was only very localized sedimentation of the pools, because of the mild winter. However, with the October and December 2021 storms, west slope erosion was extensive throughout the West Fork (photo, lower left). Most pools were filled with gravel and fines. (The typical effect is shown in the two lower middle and right photos, where large deep pools were more than 90% filled).

Lower East Fork

2021 – loss of alders and much of streamside canopy of other trees, slightly warmer water (shade from steep north slope)

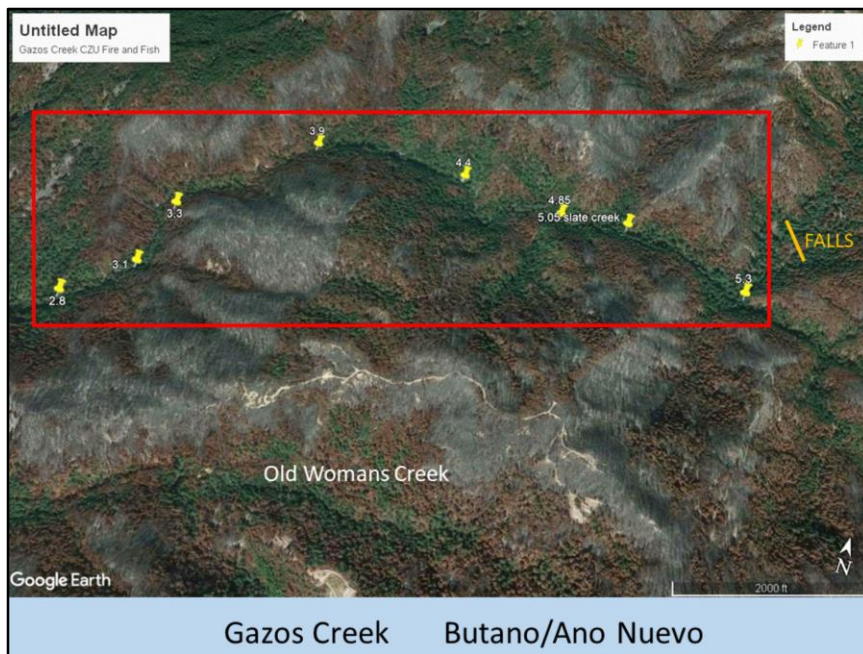
2022 – little channel change in cobble/boulder armored channel from upstream Butano Sandstone. Silt in pools but no filling.



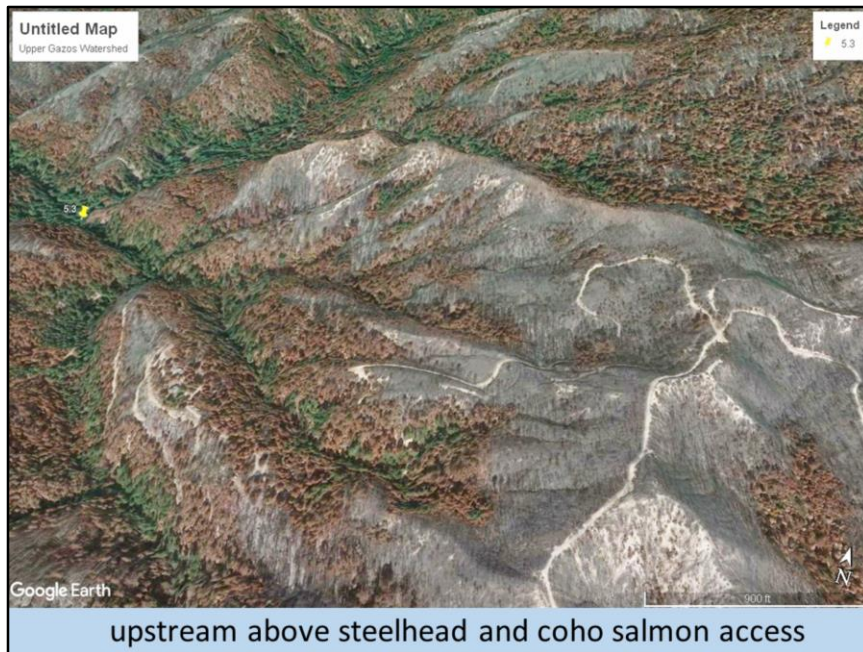
The fire burned the alders and upslope trees on the East Fork, eliminating alders and Douglas firs, but because of the northeast orientation of the stream and the steep north-facing slope, much of the shading remains.

The East Fork of Waddell Creek usually has larger flood peaks than the West Fork, but the stream bed is steeper and is armored with cobbles and small boulders from the Butano Sandstone from farther upstream. Slope erosion was apparently limited or captured within the riparian corridor. There was a coating of fine sediment in the pools, but no significant pool filling, The East Fork channel presently is in the best condition within the watershed.

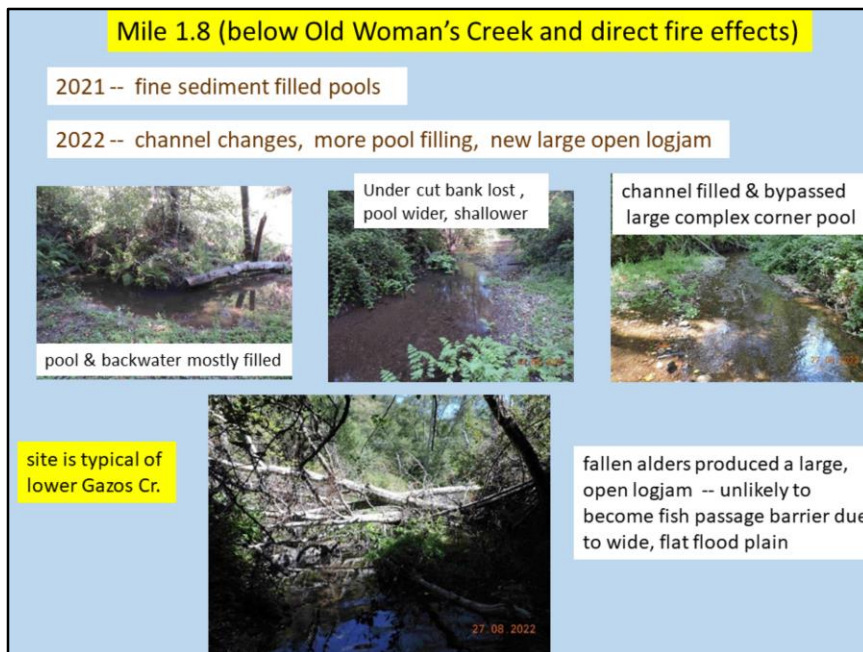
Since 1999 steelhead and coho salmon abundance on the East Fork and the main stem of Waddell Creek have apparently been affected by toxic fish kills in many years (illegal toxic waste dumping?). The very low fish abundance throughout the watershed in 2022 may be related to resumption of toxic problems and/or to the major new logjam at mile 0.65 that restricted adult fish passage in winter 2021-22. Although Gazos Creek (and Scott Creek) suffered similar channel sedimentation and pool filling by 2022, fish abundance was atypically high in those two watersheds in 2022.



Compared to Waddell Creek, the CZU Fire burned less severely to or near the channel of Gazos Creek, above mile 2.8 within Butano and Ano Nuevo State Parks. Upslope the burn was heavier than that near the stream, and was also heavy in Old Woman's Creek watershed, a tributary that enters Gazos Creek farther downstream near mile 2.0. Steelhead (and coho salmon through 2005) have access to below the falls at the Mountain Camp at about mile 5.45.



Upstream of the falls there was an intensive burn, that would be a source of sediment input downstream.



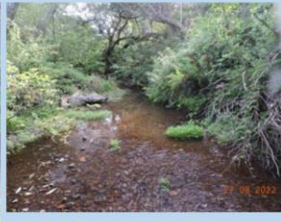
Downstream of mile 2.0, the indirect effects of the burn upstream on Gazos Creek and Old Woman's Creek were limited to fine sediment input in the first winter after the fire. However, the storms in October and December 2021 produced substantially more erosion in both watersheds and delivered it downstream throughout lower Gazos Creek. At mile 1.8 the storms and sediment filled pools (photos, upper left and middle) and rearranged the channel (photo, upper right).

The storm flows also undercut and toppled alders, including producing a large open log jam just upstream of the 1.8 mile sample site (lower photo). Alder trunks tend to break up within several years. In addition, the channel downstream of mile 2.0 tends to have a sandy, rather flat, and broad flood plain (low entrenchment). The stream tends to cut under or around fallen and accumulated wood, rarely become a durable, significant fish passage problem.

Mile 2.1 – downstream of direct fire effects

2021 – fine sediment from upstream coats streambed and fills pools

2022 -- large, tight log jam forms during high flows in narrow, entrenched channel (fish barrier), blocks upstream sediment and allows flushing of site to restore pools



At mile 2.1, downstream of direct fire effects and upstream of the mouth of Old Woman's Creek, fine sediment smothered the stream bed and filled pools in the first winter after the fire. Fish were very scarce during September 2021 sampling.

In 2022, despite more sediment input upstream from the October and December 2021 storms, the pools had recut to their original configurations, and the streambed was largely clean of fine sediment (lower photos). A large log jam of old and new wood had formed in a narrow, entrenched (limited flood plain) channel immediately upstream of the site. The new jam, which is high and tightly anchored, trapped sediment upstream and allowed the high flows to recut and clean the channel downstream. However, the new jam is likely to be a durable barrier to fish passage, unless actively modified.

Miles 2.8 - 5.3 part 1

2021 – burn had minimal effect on riparian canopy, but some fallen and cut wood added to channel. Erosion added silt to channel



2022 – storms added abundant fines and gravel to channel, filling pools

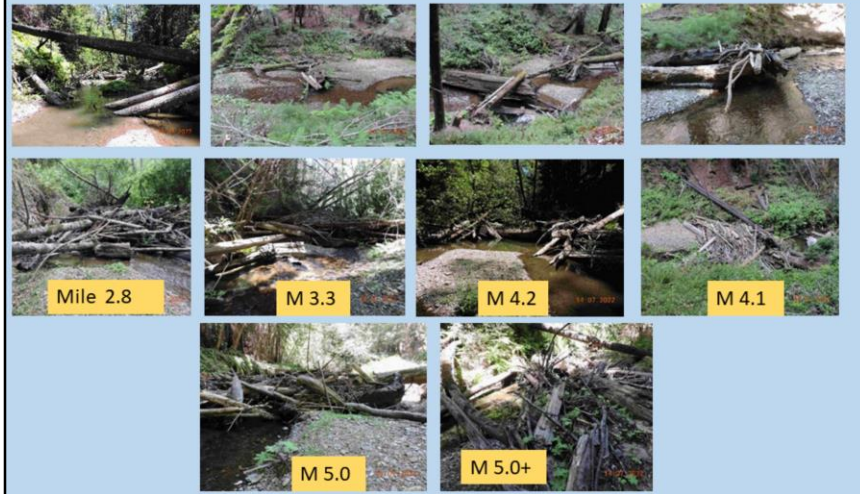


From mile 2.8 through 5.3, streamside and channel conditions responded generally the same. The fire burned to or near the stream bed, but loss of streamside trees or shading changed relatively little overall (upper photos). Temperature recorders in 2021 found little change in summer water temperatures, partly due to increased stream flow, despite the drought.

General channel conditions changed little following the mild first winter, although fine sediment was increased on the stream bed. However, the storms in October and December 2021 dumped substantial fine sediment and fine gravel into the stream and moved the slurry throughout the reach. Many pools were eliminated (photo, middle left), and most pools were substantially filled (lower photos). The loss of pools may have resulted in the spotty pattern of fish abundance, as adult steelhead apparently avoided spawning reaches without large pools. Although overall juvenile steelhead abundance in 2022 was atypically high, the scarcity of pools may affect overwinter juvenile survival.

Miles 2.8 – 5.3 part 2

2022 -- more dead or damaged trees added to channel from steep streamside slopes, aggregated by high flows and narrow/entrenched channel into 6+ log jams that are serious present or potential fish passage barriers.



Substantial new wood from fallen and cut trees was added in both years after the fire (upper photos). The storms in October and December 2021 moved the wood around in the channel and often aggregated it as log jams anchored on fallen trees in narrow, entrenched portions of the channel. Much of the Gazos Creek channel upstream of mile 2.5 is entrenched (photo, upper left) , partly because the streamside road has eliminated much of the former flood plain.

In 2022, at least 6 major log jams were present, that act as potential or actual fish passage problems (photos, lower two rows). They should be modified and monitored. The jam at mile 2.8 pre-dates the fire, and was partially burned by the fire. It enlarged and tightened by 2022. The jam at mile 4.2 was formed by a debris flow with redwood trees in 1999, and had been a fish passage problem of variable difficulty until December 2021, when more than two-thirds of the wood was dislodged by the storms. Unfortunately the dislodged wood was captured by fallen trees in the narrow channel at mile 4.1, merely moving the severe jam..

Recovery Concerns

- 1 Continued sediment from upstream in both streams and from west slope of Waddell > mile 2.8 (steep, little ground cover) – how long?
 - 2 Log jams as fish barriers, especially mile 0.65 Waddell and mile 2.1 Gazos (need to modify and monitor)
 - 3 Recovery of alders and canopy of other streamside trees (1982/83 to 1995-97 on Waddell 10-15 “good” yrs?)
 - 4 Flushing of sediment and improved pool development (1982/83 to 1995-97 on Waddell 10-15 “good” yrs?)
 - 5 Infrequent “bad” years like 1982, 1983, 1998?
- interactions and timing among “good” and “bad” years??

Continued sediment inputs from upstream and from the steep, unprotected west slope of Waddell Creek may occur in future wet years—amount and duration is unknown.

Some log jams need to be carefully modified to prevent fish passage problems. The jams at mile 0.65 on Waddell and mile 3.1 on Gazos are especially problematic, since they can block access to much of the spawning and rearing habitat.

In 1982 and 1983 major storms in the Waddell Creek watershed eroded slopes, filled pools, and ripped out riparian alders. West Fork and main stem Waddell pools were small and shallow in 1984. However, by 1995-1997 riparian alders and shading had substantially improved, and pools had been recut and substantially flushed of sediment. However, the 1998 El Nino and 1999 wet year reversed much of the gains.

Recovery time will depend on the interactions and timing among “good” years that speed recovery and “bad” years that make things worse.