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TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE — SOIL CONSERVATION SERVICE

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Davis, California
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EXCERPT FROM
"SOIL HEATING IN CHAPPARAL FIRES"

The Pacific Southwest Forest and Range Experiment Station has just issued a very worthwhile State-of-the-Art publication on fire and chapparal soils. It is entitled "Soil Heating in Chapparal Fires: effects on soil properties, plant nutrients, erosion, and runoff", by DeBano, Rice, and Conrad; Research Paper PSW-145, 1979.

The section on soil erosion is attached for the information of those offices that might find this useful in developing land use alternatives with cooperators.

Copies of this publication can be obtained by writing to:

Publications
Pacific Southwest Forest and
Range Experiment Station
P. O. Box 245
Berkeley, CA 94701

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Attachment

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little water available for overland flow on the surface. Further, chaparral soils and geologic parent materials are characteristically permeable compared to prevailing rainfall intensities (Krammes 1969). When surface erosion occurs, it is generally restricted to established rills and gullies. As an example of the effect of these characteristics of chaparral watersheds, consider the behavior of research areas on the San Dimas Experimental Forest during a large storm in March 1938. Less than 1 percent of the precipitation was measured as surface runoff on research plots, even though streamflow from various experimental watersheds ranged from 16 to 38 percent of the storm precipitation (Coleman 1953).

The relative stability of the chaparral watersheds is changed by wildfires and investigators find that high rates of runoff and debris usually follow burning (Krammes 1965, Krammes and Osborn 1969, Rowe 1941, Sinclair 1954). These high runoff rates result partly from a marked intensification of a water repellent layer. This layer greatly decreases infiltration rates and reduces the hydrologically active portion of the watershed surface from a meter or more in thickness to only a few centimeters. This means that relatively small storms and low rainfall intensities can produce substantial amounts of overland flow and result in substantial sheet and rill erosion. DeBano and Conrad (1976) found 34 times more soil and debris moved on a 50 percent slope following a moderately intense prescribed burn than on a similar unburned area. The erosion rate for burned plots was 7340 kg per ha and for unburned plots was 211 kg per ha. It seems reasonable to assume that an increase in overland flow also increases gully erosion. The significance of an increase in overland flow is not that it directly increases erosion; rather, the increased flow provides a transporting mechanism for landslide and dry ravel deposits which have accumulated near the stream channel. On an average, nearly 70 percent of the long term sedimentation movement on chaparral watersheds occurs during the first year after fire (Rice 1974). Most of the increase in sediment does not result from erosion occurring at that time, but results from remobilization of existing deposits.

Debris production from chaparral watersheds seems to be a two-phase process. Although erosion on side slopes is primarily by gravity-activated landslides and dry ravel, some debris is delivered to the channel by overland flow after fires. These processes deliver sediment to gentler slopes (often adjacent to stream channels) where they can no longer operate. From here, flowing water acts as a mechanism for sediment transport. About 25 percent of the chaparral areas are steep

Runoff and Erosion

Fully vegetated, unburned chaparral watersheds, in common with other forested watersheds, seldom show overland flow. Surface litter promotes infiltration by reducing a raindrop impact and impeding overland flow, thereby providing temporary storage for short periods of high-intensity rainfall. High infiltration rates and the storage capacity of chaparral soil leave

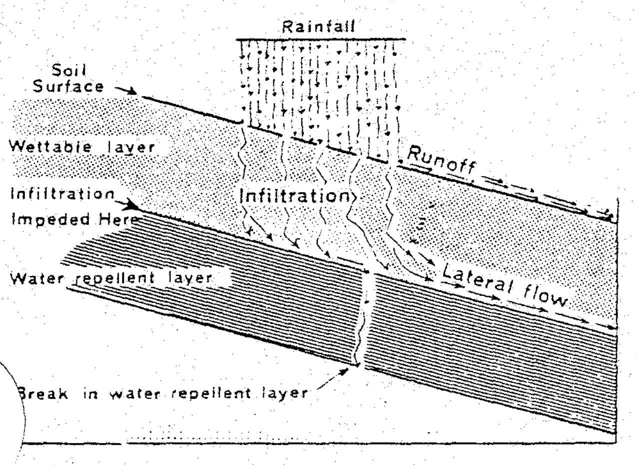

Figure 12—A water repellent layer impedes infiltration and causes surface runoff.

enough for gravity-related erosional processes to operate. If erosion were directly related to steepness of slope, this 25 percent of the chaparral would produce about half of the area's sedimentation. Recent data suggest that the proportion of sediment coming from these steep slopes may be much higher. DeBano and Conrad (1976) found that following a prescribed burn, plots on 50 percent slopes yielded about 250 percent more surface erosion than did plots on a 20 percent slope.

Landslides may account for about half the erosion on steep chaparral slopes (Rice 1974). Landslides are relatively infrequent and are dependent upon storms of such a size that they occur only once every 8 years, or less frequently. Consequently, the importance of landslide erosion has been underestimated in the past and few studies have been concerned with measuring it (Rice and Foggin 1971, Rice and others 1969). Data from these studies and the observations of other investigators (Campbell 1975, Scott and Williams 1974), however, tend to support the importance of landslides. Immediately after fire, surface erosion and movement of existing sediment stored in channels dominates the erosion process. Reduced infiltration rates make landslides less likely. Later, landslide erosion on recently burned areas increases because roots of fire-killed vegetation decay. Rice (1974) reported that the volume of landslide erosion on an area which had burned 9 years previously was over 18 times greater than on a chaparral-covered area which had not burned for 50 years. While landslides usually occur during large storms, they often produce debris in excess of the stream's ability to transport it out of the watershed. Such deposits accumulate in a pseudostable condition near stream channels.

Dry ravel produces about one-third of the erosion from steep unburned chaparral watersheds (Rice 1974). Annual rates of dry ravel ranging from 224 to 4300 kg per ha have been measured by Anderson and others (1959). Later, Krammes (1965) found about 45 percent of the surface erosion occurring during the dry season and 55 percent during the wet season. During the wet season, sheet and rill erosion occurred and, in the dry season, dry ravel occurred. A later study (Krammes and Osborn 1969) found that at least one-third, and perhaps as much as three-quarters of the wet season erosion was actually occurring as dry ravel between rainstorms. Taking this into account, we find that from 63 to 86 percent of the surface erosion is dry ravel. Rates of dry ravel erosion are also affected by fire. On an unburned watershed much potentially unstable soil is perched behind stems and litter and prevented from moving downhill by gravity. When the fire destroys these barriers, dry ravel immediately begins. Krammes (1960) measured a nine-fold increase in dry ravel erosion during the first year following fire. In the first 88 days after the fire, 89 percent of this erosion occurred. Since dry ravel occurs when there is little or no streamflow, debris routinely accumulates in deposits at the base of steep slopes. These deposits, together with untransported remnants of landslide debris, act as magazines supplying readily transportable sediments to high stream discharges whenever they occur.