have done. If only a small amount of secondary deposit is laid down, the wall will be thin and the fiber relatively immature and fine. However, if conditions of growth are favorable, deposition of cell-wall substance will continue and the wall will become thicker and the fiber relatively more mature and coarser. Relatively fewer of the well-developed mature fibers will be required in the cross section of a yarn of given size, than of the lesser developed, immature fibers.

Although cotton fibers from varieties that normally produce medium or coarse fibers may be fine as a result of immaturity alone, this type of fineness is not necessarily advantageous from the standpoint of ease of spinning and quality of yarn. Too great fineness from this cause may introduce distinct difficulties into the spinning processes, and contribute to nep formation and to unsatisfactory dyeing properties of yarn and fabric. Thus, while a given degree of fineness corresponds always to the same average number of fibers in a yarn of given size, there is a qualitative difference in fineness that depends upon the thickness of the fiber walls. Because of the flattened form of its cross section, an immature fiber should be, theoretically, much less rigid or stiff than a mature fiber of the same wall cross section. Perhaps this explains the seemingly greater tendency for thin-walled cotton fibers to form neps as compared with thick-walled fibers.

From the theoretical standpoint and assuming identical composition, it might be assumed that a yarn made from immature fibers should possess the same strength as one made from mature fibers, fineness and other factors being the same. Or, if the greater flexibility of the thin-walled fibers is advantageous, the yarn made from immature fibers might be even the stronger. Limited observations indicate that this relationship is by no means simple and that considerable work will have to be done before the relationship of fiber maturity to yarn strength can be determined.

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FOREST Cover Proved a Controlling Factor in Flood Prevention Man's mistreatment of the soil or of its natural forest or other vegetative cover as a cause of increasingly destructive erosion has been convincingly pointed out by studies recently conducted by the Forest Service in California. In these studies large soil tanks and $\frac{1}{40}$-acre plots in the mountains produced evidence that vegetation not only obstructs and retards the run-off of surface water, but also, by means of the leaf litter, and the action of the roots, keeps the topsoil so porous that a large proportion of rain water percolates continuously into the soil to join underground supplies. Litter-covered soil was found to absorb 5 to 10 times as much water as that absorbed by bare soil. Run-off was just the reverse—10 to 30 times as great from bare soil as from litter-covered soil. Generally 100 to 1,000 times more soil was swept away from bare soil plots than was eroded from forest-covered plots, and the rate of erosion increased as the intensity of rainfall increased.

When these results are applied to field conditions, the conclusion is that gentle rains, if well distributed through the season, cause little or no damage on newly burned areas, since they do not bring sufficient water at any one time to produce erosive run-off. Heavy rains, however, with an intensity of 1 inch or more per hour even though of brief duration, quickly puddle the surface soil, seal the soil pores, and start a rapid process of gully erosion. When this stage is reached, the excess water, unhindered by the usual chaparral cover with its accompanying carpet of leaf-litter, rushes down the barren slopes gathering up soil and rock fragments in ever-increasing size and volume until it reaches the bed of the stream. There the accumulated flow is soon swelled to a raging torrent, sweeping all before it, scouring the channel, snapping trees from their roots, plucking huge boulders from deep embedments, and finally surging forth upon the valley floor in great destructive waves of mud, debris, and boulders.

In southern California, where the mountains are covered with an "elfin forest" of highly inflammable chaparral, frequent forest fires and the characteristic heavy rainstorms of the winter season are re-

FIGURE 32.—This Montrose cottage is one of the 400 homes wrecked by the New Year's flood from the fire denuded watershed. The great gully in foreground carried away lawn and garden.

sponsible for numerous highly localized "burned area" floods. On the last day of 1933 there occurred in the Verdugo Creek watershed of Los Angeles County a flood which, because of the urban development in its path, was the most tragic and destructive single flood since the white man came to California.

A storm of record volume, beginning on December 30, a little more than a month after a severe forest fire had swept the mountain slopes above the valley and reduced their chaparral cover to ashes, poured 12 inches of rain upon the steep and barren slopes within a period of 56 hours. The ensuing mud flows reached their climax at midnight on New Year's Eve and swept through the towns of La Crescenta, Verdugo, and Montrose in numerous streams with such force that boulders weighing from 20 to 50 tons were carried thousands of feet and deposited on the city streets. In each stream path suburban homes were wrecked and their gardens either gouged away by deep gullies or buried under mud and boulders (fig. 32). In the small residential valley of La Crescenta 34 persons were swept to their death, and property, including more than 400 homes, was destroyed or damaged to the extent of $5,000,000 (fig. 33).

Such torrential floods are usually reported as having been caused by a cloudburst, regardless of the condition of the watersheds from which they issue, and in the absence of adequate data it is difficult to prove the true causes. In this case, however, a study of rainfall, run-off, and erosion throughout the storm area was immediately undertaken by the Forest Service and Los Angeles County flood-control authorities, and information obtained that permitted comparison of storm results in the La Crescenta area with those in the surrounding territory. It was found that the rainfall was remarkably uniform over a foothill and valley area approximately 20 miles wide by 50 miles long. Some 30

FIGURE 33.—Boulders weighing 60 tons each deposited on a street of La Crescenta by the New Year's flood from Dunsmere Canyon.

stations in the area measured an average rainfall of 13.03 inches, while the average on the burned watershed was 12.56 inches.

Run-off Greater from Burned Area

The peak run-off of water in streams from the burned area was conservatively calculated at 500 cubic feet per second per square mile, plus at least an equal volume of solids, making a total flow of 1,000 second-feet per square mile of watershed (fig. 34). In striking contrast, the simultaneous peak flow from the well-forested Arroyo Seco watershed, contiguous to the burned area, was only 58 second-feet per square mile, although rainfall in the Arroyo was 14.85 inches, or more than 2 inches greater than in the burned area. In the San Dimas Experimental Forest, 20 miles east of La Crescenta Valley, several well-forested unburned watersheds yielded peak flows averaging only 53 second-feet per square mile from 10.8 inches of precipitation.

FIGURE 34.—Dunsmere Creek, ravaged by flood from the burned area. Line of boulders near the building indicates extent and force of the torrent. All trees were torn from the stream banks, and rock-mattress check dams were swept from its bed. Man stands near the remains of one of the wire-bound dams. Compare with figure 35.

Enormous Erosion from Burned Area

Surveys showed that 659,000 cubic yards (more than a million tons) of soil and boulders were caught in debris basins or deposited on the Crescenta Valley floor, in addition to unknown quantities of lighter material carried to the ocean. These figures are more significant in that the burned area of 7 square miles comprised only one-third of the Verdugo Creek drainage basin. With ample allowance for material scoured from channels beyond the burn, this shows an erosion rate of

FIGURE 35.—Arroyo Seco Creek, undamaged by storm run-off from forest-covered watershed adjacent to the burned area. White line shows high-water mark of the New Year's storm. The water, being clear and controlled, was harmless. Compare with figure 34.

at least 50,000 cubic yards per square mile of burned watershed during the storm.

In the unburned watersheds, however, erosion debris caught by reservoirs of the experimental forest amounted to only 52 cubic yards per square mile. Erosion measurements from Arroyo Seco were not obtainable, but forest officials reported that the high water of that creek was practically clear and that the small amount of silt which it carried came directly from the gullying of a newly-built highway in the canyon. The condition of the creek bottom after the storm (fig. 35) verifies this observation and indicates that erosion rates in the Arroyo Seco must have been very similar to those in the San Dimas area.

Forest Fires Must be Prevented

These records show that removal of the forest cover by fire increased the run-off rate of the heavy New Year's storms more than eight times the normal, and accelerated the rate of erosion nearly a thousand times, raising it from a trifling and completely harmless amount to quantities of enormous destructivenss. The La Crescenta burn was only 7 square miles, but in Los Angeles County alone there are 1,300 square miles of mountain area subject to fire and capable of building up disastrous floods. A considerable amount of developed property in the county has been safeguarded by dams and other costly flood-control structures, but outside the protected sections property to the value of $300,000,000 is still menaced by fire and flood.

Leading engineers of southern California have joined with foresters in the following conclusions:

(1) The native brush cover in the mountains of California affords a natural control against excessive run-off and destructive erosion.

(2) The La Crescenta disaster resulted from denudation of the watershed by the November fire, rather than from the heavy rainfall.

(3) The continued effectiveness of flood-control reservoirs requires the prevention of excessive debris deposition therein; this can be economically accomplished only by a good cover of vegetation on the watersheds.

(4) The total benefits deriving from the natural cover of southern California mountains are such that no reasonable expense should be spared to protect that cover from fire.

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FOREST Removal Affects Local Climate and Growing Conditions

Any modification of climate caused by the removal of the forest is of chief interest to man through its effect on the vegetation which follows the forest, particularly that part of the vegetation ultimately used for food or for construction. On lands unsuited for agriculture it is the second-growth forest—the source of our future wood supply—which must survive the local climate as modified by the removal of the original forest.

Comparison Between Wooded and Denuded Areas

Studies made by the Allegheny Forest Experiment Station in the woods and in cut-over areas nearby show to what extent the climatic agencies which profoundly affect the growth of vegetation, such as