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The coastal slopes of the San Gabriel mountains in southern California are wildlands on which intensive management is justified. These watersheds lie directly above heavily populated urban areas and highly developed industrial complexes. An adequate vegetation cover on the watersheds is valued for several reasons---primarily to protect against flood and erosion damage, but also to promote yield of local water and to provide recreation areas and wildlife habitat.

Intensive management requires that some changes be made in the native plant cover--for example, the conversion of brush to a different type of vegetation on selected areas. One purpose of selective brush conversion is to break extensive brushfields into smaller units for more effective control of fires. Under the typically hazardous conditions which prevail most of the year in southern California, fire control is extremely difficult in continuous dense brush. The brushfields can be broken up by establishing fuel-breaks at strategic locations. Fuel-breaks are wide strips of land on which the heavy brush cover is converted to vegetation with lower fuel volume and less resistance to fire control. Reduction of acreage burned by the few large fires which escape initial attack is the aim--and this is the key to reducing floods and erosion.

Selective brush conversion also has other purposes. It can increase water yield by removing excess woody vegetation from canyon bottoms and some slope areas of deep soil (Rowe and Reimann, 1961). Removing hazardous woody fuel from some areas of high recreational value can make them more accessible and protect natural or planted groves of trees from being destroyed by fire. Wildlife habitat will be improved if the brushfields are broken up with areas converted from brush to grass, and new range for livestock, if needed, can be developed on limited favorable sites.

But the watersheds represent extremes in steep terrain and shallow rocky soils. Dry, hot weather prevails much of the year. These physical factors definitely limit the feasibility of converting the native brush to a different vegetation type over large areas. How can brush conversion objectives be fitted to such watersheds?

A look at the results from a soil survey of the San Dimas Experimental Forest, which includes two typical San Gabriel drainages, shows that the choice of areas for conversion will be strongly affected by steepness of slope and depth of soil. More than 80 percent of the experimental forest has steep or extremely steep slopes, and almost 75 percent has shallow or very shallow soils (table 1). These characteristics affect not only the possibilities for changes in cover type but also the practicability of conversion techniques.

Table 1.--Percent of acreage on the San Dimas Experimental Forest, by slope gradient and soil depth classes

Steepness of slope	Dominant depth of soil: Very shallow, Under 1 foot	Shallow, 1 to 2 feet	Medium, 2 to 3 feet	Deep, 3 to 4 feet	Deep, Over 4 feet	All depths
	Percent					
Moderate to steep						
Under 40[1]	--	2	3	1	1	7
40-55	(2/)	2	3	1	(2/)	7
Steep						
55-70	4	23	12	3	(2/)	42
Extremely steep						
Over 70	34	9	1	--	--	44
All gradients	38	36	19	5	2	100

1/ Dominant slope gradient, in percent.
2/ Less than 1 percent of the acreage.

Steepness of Slope

Brush conversion is limited more by slope gradient than by any other physical factor. The most effective and economical methods for each step in the conversion process--removing brush, sowing grass, and killing brush regrowth--involve use of tractors and other ground equipment. On terrain, like that of the experimental forest, tractors can be used on only limited acreage, and much of this acreage is not accessible without expensive road construction. Excessively steep terrain restricts brush conversion methods to aerial applications which are less positive than those using ground equipment, and to hand applications that are extremely slow and costly on slopes too steep for easy foot travel.

In consideration of these limits, steepness of slope on the experimental forest has been mapped in classes (fig. 1):

Moderate to steep slopes.--This class includes all slopes with gradients from 0 to 55 percent, 55 percent being about the maximum on which a heavy tractor can be used. Out of the 17,000 acres within the experimental forest, 14 percent of the land was mapped in this class.

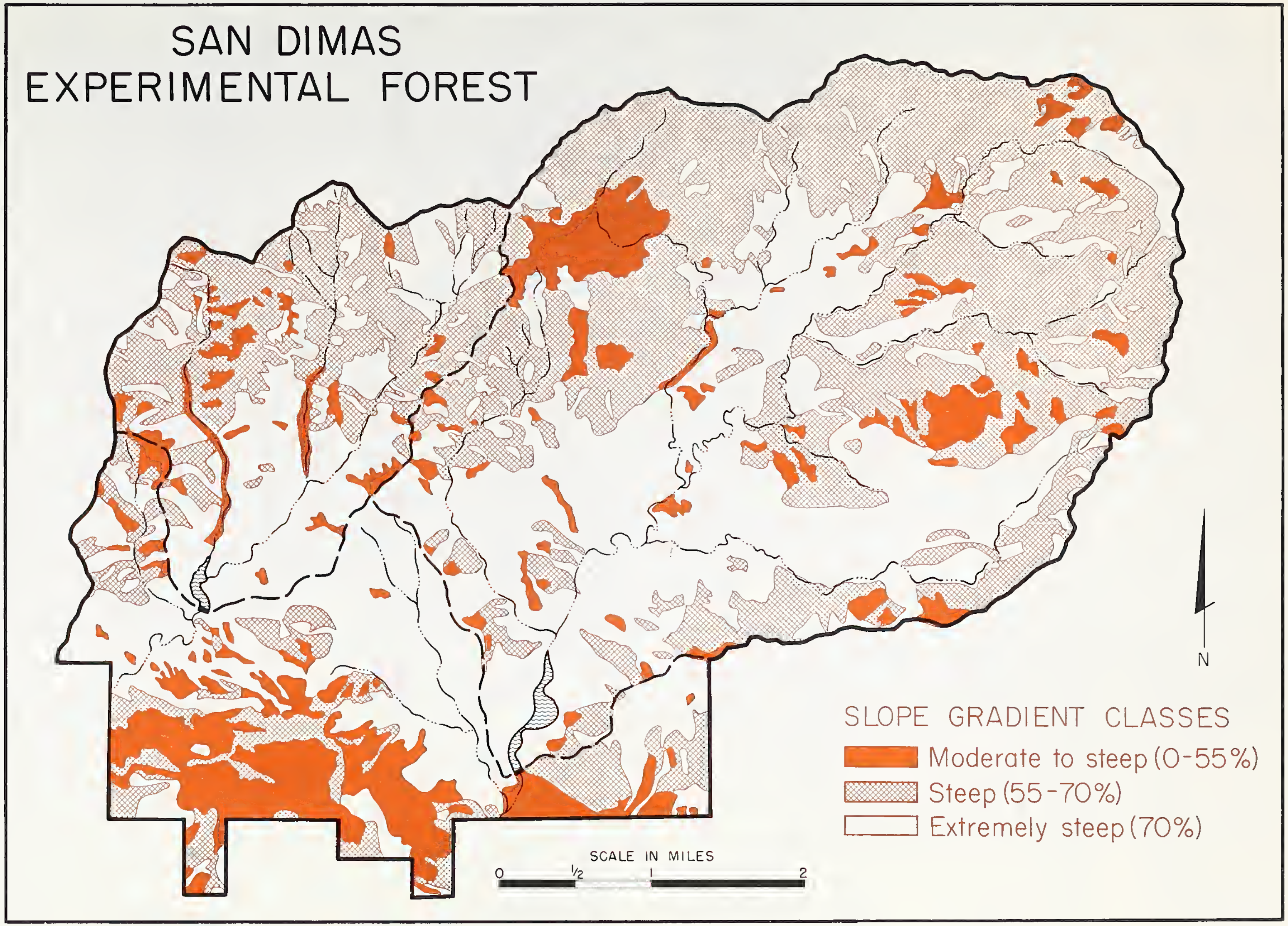

Figure 1.--Slope gradient classes on the San Dimas Experimental Forest.

About half of this acreage has slopes under 40 percent gradient, on which bulldozers can be used most safely and efficiently. Some additional areas too small to be mapped can be worked with a tractor along ridges and in canyon bottoms. The moderate to steep slopes are incised with steep-sided drainages that cannot be readily crossed, which reduces the workable acreage and makes tractor operation expensive.

Steep slopes.--This class includes all areas having slope gradients dominantly between 55 percent and 70 percent; these areas are too steep for ground equipment and are difficult to cover on foot. Included in this class are many small slope facets with steeper gradient, which make foot travel even more difficult. This slope class was mapped on about 42 percent of the total acreage.

These steep slopes when cleared must be revegetated by aerial sowing, which has given erratic results, especially on south exposures. Helicopter spraying will eliminate much of the brush regrowth, but the necessary follow-up spraying by hand is time-consuming and expensive, especially on long slopes, many of which are long distances from roads or tractorways. Consequently, brush conversion on this kind of land should be held to that necessary for fire control purposes or to areas from which increased water yield, or other values, are assured and on which the new cover will provide adequate protection from runoff and debris movement.

Extremely steep slopes.--This class is made up of areas with slopes mainly greater than 70 percent gradient. These slopes are steeper than the angle of repose and exceedingly unstable. Loose soil and rocks move downhill by gravity. Hand work is dangerous as well as difficult. The costly job of brush conversion by aerial applications and hand work on such slopes cannot be considered justified or advisable unless it is essential for fire control. Special work to stabilize the soil may be necessary if the brush is removed.

These most unfavorable sites are predominant on the experimental forest; they were mapped on 44 percent of its area.

Depth of Soil

On slopes of favorable gradient the advisability of converting the native brush to a new cover is determined to a large extent by the depth of the soil. For example, coarse-textured soils less than a foot deep rate low in productivity for growth of a new cover because of inadequate soil-moisture holding capacity. Soils 2 feet or more in depth are considered adequate for growth of a full herbaceous cover. Usually, they are also the soils on the experimental forest that have the finer texture and higher fertility needed for producing a full grass cover. Soils 3 feet or more in depth rate highest in potential for increased water yield after an herbaceous cover has been established because in these soils water storage is possible below the use-zone of shallow-rooted plants (Rowe and Reimann, 1961).

Experience and research to date permit broad, relative ratings of the soils of different depth, but their actual productivities for growing grass or yielding water have not been determined. Studies seeking to refine these ratings have been started on the experimental forest (Hopkins, Bentley, and Rice, 1961). Until this information is available, decisions concerning the economic advisability of converting brush to grass must be based on relative ratings of different soil depths.

Three broad classes of soil depth were mapped on the experimental forest (fig. 2):

Medium and deep soils.--Medium depth and deep soils (table 1) are grouped together on the generalized map, but their potentialities are considerably different.

Soils of medium depth (2 to 3 feet) are adequate for production of a good plant cover, but the possibilities for greatly increasing water yield by changing brush to grass on these sites are questionable. However, some increased yield due to greater water storage in the soil during dry seasons can be expected from the spots of deep soil known to occur within areas mapped as medium depth soil, and possibly from spots of deeply weathered parent material below the soil profile itself. Studies are underway to determine whether brush conversion on these medium depth soils is worthwhile for water production alone.

The 2- to 3-foot soils were mapped on 19 percent of the experimental forest acreage. About 6 percent was on slopes under 55 percent gradient where conversion is most feasible and seems justified at present. Almost all of the remaining 13 percent was on slopes of 55-70 percent gradient on which conversion is questionable unless essential for fire control purposes.

For areas of deep soil (more than 3 feet deep) study to date indicates that increase in water yield should be obtained by changing the cover from brush to a shallow-rooted herbaceous cover (Rowe and Reimann, 1961).

Deep soils were mapped on about 7 percent of the experimental forest. Of this, more than half was on slopes under 55 percent gradient, and the remainder on steep slopes where conversion will be difficult and costly.

Shallow soils.--These soils (1 to 2 feet deep) have questionable productivity; on favorable gradient the soil may produce an adequate grass cover. Within the mapped acreage of shallow soils, however, little increase in water yield is expected from removal of the brush. At present, conversion should be restricted to areas on which grass is needed for a specific purpose, such as to break up brushfields for better fire control.

Shallow soils occur extensively, being mapped on 36 percent of the experimental forest. Of this, only 4 percent was on slopes of less than 55 percent gradient.

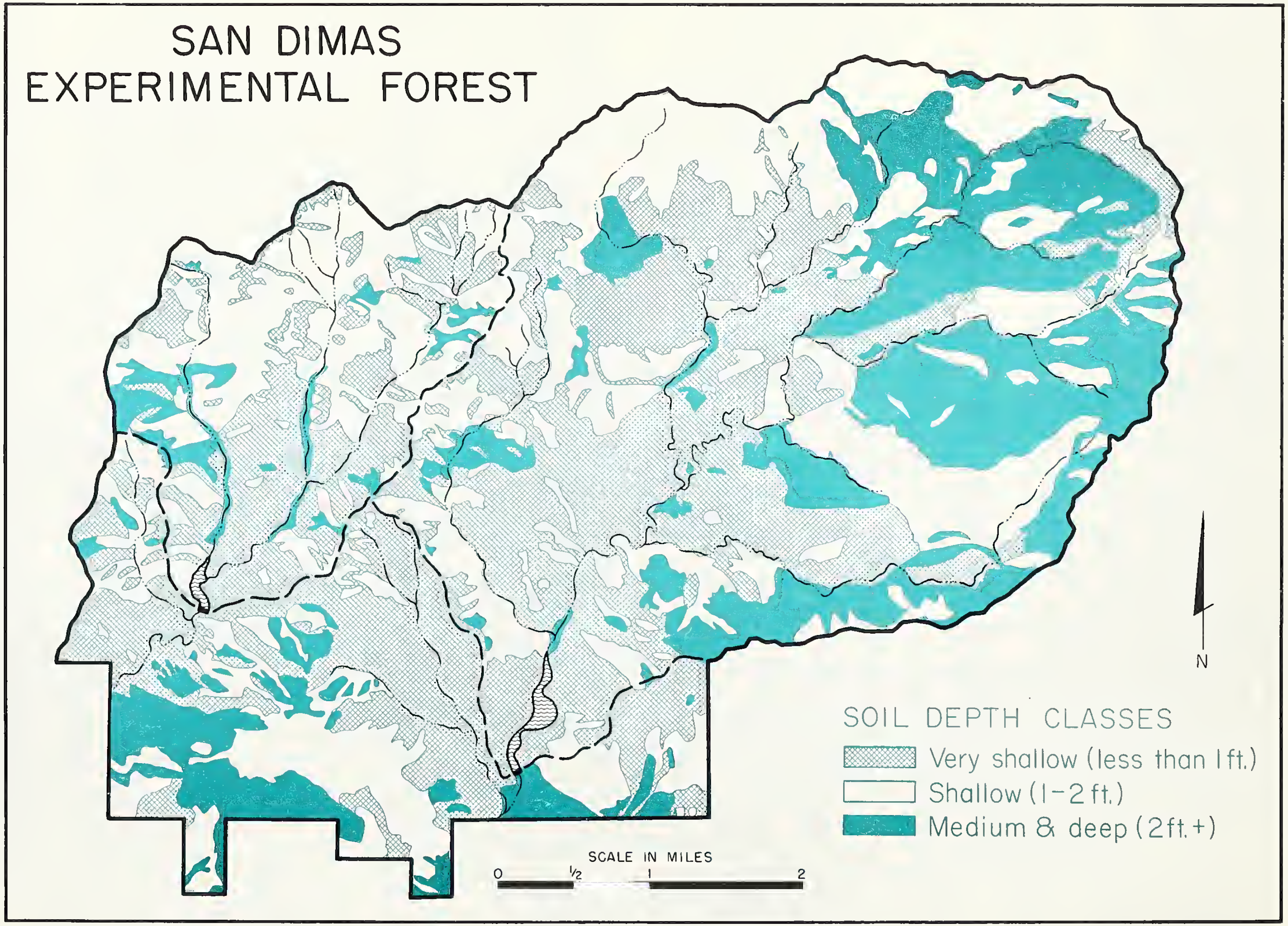

Figure 2.--Soil depth classes on the San Dimas Experimental Forest.

Very shallow soils.--Such soils (less than 1 foot deep) are rated low in overall productivity. Brush conversion should be limited to areas on which a lighter cover is essential for fire control.

This too is an extensive soil class; it was mapped on 38 percent of the experimental forest, and 34 percent on slopes greater than 70 percent gradient.

Selecting Brush Conversion Areas

It is plain that only a limited acreage could be called first priority sites for brush conversion aimed strictly at economical improvement in resource values. However, the experimental forest also contains a considerable acreage of questionable suitability on which removal of excess brush may pay in terms of water yield. All of this acreage should be shown on a map before final selection is made of areas to be converted.

First priority sites include the canyon bottoms and the slopes with gradient less than 40 percent and soils more than 2 feet deep. The accesible land of this kind is estimated at about 5 percent of the experimental forest.

An additional 4 percent is made up by high priority sites with slope gradients between 40 and 55 percent and soils deeper than 2 feet. These sites can be cleared efficiently. They should produce a good soil cover and probably some increased yield of water.

Slopes having gradients of 55-70 percent and soils more than 2 feet deep are questionable for clearing until research determines whether increased water yield will pay the conversion costs on long steep slopes, and whether extensive clearing will produce problems of soil stability. These sites include about 15 percent of the experimental forest.

In fitting brush conversion to the experimental forest, areas to be cleared for increased water yield will be selected first. Then selection of additional conversion areas will be based on fire control needs and on accessibility of the areas to men and equipment (Bentley and White, 1961). As far as possible the wide fuel-breaks, on which the brush fuel will be changed to a grass cover, will include the areas of high priority for other purposes. To connect the fuel-breaks into a complete system, preference will be given to clearing brush from sites that will yield water even though the increased yield may be small.

Obviously, brush conversion should be done on the most accessible and least steep areas, on which the work is most feasible. Thus, many fuel-breaks will be located in canyon bottoms and on rounded ridgetops to include a minimum of steep slopes. Areas cleared of brush on steep slopes will be kept individually small so that possibilities of increased erosion from brush removal will be at a minimum.

Despite the generally unfavorable site conditions in the San Gabriel Mountains, brush conversion on areas selected for a specific purpose can develop a new vegetation pattern that will greatly benefit control of fire and will result in more intensive multiple-use management.

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