500

Kay

Hydrologic Studies on California Brush Ranges

By
R. L. Ferral and R. H. Burgy[1/]

Introduction

California's brushlands and woodland-grass areas have been variously estimated at 18 to 45 million acres (2, 3). Much of this difference in estimates is based on definition and viewpoint. How many trees per acre can a grassland support without becoming woodland-grass? Is a dense stand of mixed oaks, digger pine, and other uneconomic trees a forest, or is it brushland? Areas of sagebrush and desert shrubs are commonly excluded from these estimates (3).

Wild lands where woody vegetation predominates in California include desert and semi-desert lands with low scattered shrubs, woodland-grass areas with scattered blue oak and a grass understory, mixed chaparral, chamise lands, non-commercial forests, and timber lands. These various types are sometimes well defined, but they often grade into each other or occur as patches in other vegetative types.

With the exception of commercial timber, this woody vegetation has little value. It provides some feed for livestock and wildlife. Some of it is cut for fuel or for the manufacture of furniture and novelties. In the absence of other cover it provides some protection against soil erosion, helping to hold the hillsides in place and prevent sediment accumulation in rivers and reservoirs.

No single management program could be recommended for this great, diverse area of brushlands. Much of it has been cleared in the past and more may be cleared in the future for dry-farmed grain, irrigated pasture, or more intensive

---

[1/]Junior Specialist, and Assistant Professor of Irrigation, Respectively, Department of Irrigation, University of California, Davis, California.

cropping. Some of this brushland is burned or logged timber land, which should perhaps be returned to timber. Much of it is potentially good rangeland, which should be managed primarily for forage production. Some of it is too rough to be good grazing land, and should be managed as watersheds. In some areas the highest potential value of this land may be for recreation or for future residential expansion.

Any land management planning should include some consideration of the effects of the management program on all compatable land uses. Particular concern has been expressed in this state about the effects of brush range improvement practices on watershed characteristics, especially annual runoff, flood peaks, and erosion.

Discussion

One approach to determining the relative merits of brush and grass as a watershed cover is to consider the vegetative factors involved in rainfall disposal and soil movement. First let us consider water yield. Much of the brush and non-commercial tree cover on our wild lands consist of evergreen species. Live oak, digger pine, madrone, manzanitas, ceonothus, and chemise--all are evergreens. These plants use water throughout the year, whenever soil moisture is available and weather conditions favor evaporation. Deciduous shrubs and trees usually form a minor part of the cover, except for blue oak, which is dominant in much of the woodland-grass area. These deciduous woody plants use water during five to eight months of the spring, summer, and fall. Range grasses have a shorter, cooler season of use. The annuals germinate with the fall rains, grow during cool weather, and set seed and die in late spring. The perennials grow from fall to late spring, with a summer dormancy. The roots of shrubs and trees extend throughout the soil mass of our upland soils. Grasses do not root so deeply. Since water yield is the difference between rainfall and evapotranspiration, the lighter use from a shallower soil

mass must result in greater yield of water from a grassed watershed than from a watershed covered with brush.

Erosion from soil under grass and brush is more difficult to compare. A good grass stand is an ideal erosion retarding cover. Raindrop impact is absorbed by the leaves and stems, so water reaches the soil with little force. At the ground surface numerous living and dead stems and leaves retard overland flow, promote infiltration, and prevent rapid, channelized, erosive runoff. Grass that has been overgrazed and trampled, on the other hand, may leave much bare soil exposed to raindrop impact. The soil surface is made compact and less permeable by livestock trampling, so more water must run off. Livestock trails may provide channels for the concentration of runoff and erosion. Livestock may erode the soil directly, by slipping and sliding on the hillsides and kicking soil downhill. Brush also provides variable erosion conditions. An open deciduous cover, like some of the oak-woodland-grass ranges, is essentially a grass cover with some additional soil protection by the fallen leaves caught and held by the grass. Dense mixed chaparral in sheltered canyons may promote the buildup of a thick leaf litter, especially where much of the cover is deciduous. But on much of the brushy areas, the evergreen shrubs and trees shade out all grass, the few leaves dropped are washed away each year, and the brush acts as a leaky unbrella over bare soil. An erosion pavement may form under a dense brush canopy. Such brush is a poor watershed cover, but it can be made worse. Fire without revegetation may cause greater soil loss. This often occurs for some time after a wildfire and in the first season after a controlled burn.

Flood producing conditions can also be considered from a rational viewpoint. In Northern California, rainfall intensities are relatively low. Storm intensities seldom exceed the initial infiltration rate of the upland soils, so surface runoff is usually delayed until the entire soil profile has been wetted. Floods

occur when prolonged rainfall over a large area results in high runoff rates from the entire area at one time. Under these conditions watershed cover can have little effect on flood peaks. Grassed areas may produce flow earlier in the season than brushy areas, since they have more residual soil moisture and less rainfall is required to satisfy storage. Late season flow is also likely to be greater from grassy areas, since the late spring use of water by grass is less than that of brush. But the major floods resulting from prolonged excessive winter rains would not be modified by converting from brush to grass.

Irrigation Department Research

For more than twenty years the Irrigation Department of the University of California at Davis has been studying the hydrologic effects of replacing brush with grass. Early small plot studies indicated that water losses could be reduced by removing brush, without reducing infiltration or increasing erosion or surface runoff (4). We now have seven major watershed installations, located in Shasta, Tehama, Mendocino, Placer, Mariposa, Madera, and Tulare counties. New studies are planned for Santa Barbara and San Bernardino counties. The watersheds now being studied range in size from less than one acre to 4,000 acres. Generally they consist of pairs of similar watersheds equipped with rain gages, runoff gaging stations, and erosion measuring equipment. Many local ranchers and farm advisors cooperate in collecting these data. The first step is to calibrate the watersheds in their natural state--a three to ten year process. This establishes normal relationships between the watersheds under various weather conditions. Then a vegetation removal treatment is applied to one of the paired watersheds. This has consisted of fire alone, cutting or crushing the brush before burning, and stripping the brush with a bulldozer with a follow-up burn. The treated watershed is then seeded to an adapted grass mix. Sprout control by chemicals has been necessary to prevent regrowth of brush. The new forage is utilized fully in most cases. In some instances grazing has been

excessive. Overgrazing is liable to occur whenever a small part of a large area is improved. The reseeded species are often more palatable, or palatable for a longer season, than the native grasses, so livestock tend to concentrate on the improved areas. Measurements are continued after treatment to determine the effects on total runoff, erosion, and peak flows. Of the seven installations we are now operating, one was treated in 1949, two in 1953, two in 1956, and one in 1957. One was installed this year.

Results

In all watersheds where brush was removed, an increase in average annual runoff has been noted (1). This increase has ranged from about an inch to about 3.5 inches at the various stations, averaging roughly two inches. Figure 1 shows runoff relations of treated versus untreated watersheds at Ono.

In most cases, a good stand of grass was secured in the year following treatment. Two exceptions to this occurred. On the very small watersheds at Ono in Shasta County, the first seeding was harvested by birds, rodents, and insects. A high seeding rate in a later season resulted in a good grass stand. In another treated watershed a high concentration of cattle resulted in extreme overgrazing and trampling in the first season after seeding. The grass seedlings had no chance to become established.

Erosion rates have been closely related to cover conditions. During the first winter following brush removal, erosion was accelerated. The new grass cover did not develop rapidly enough to protect the soil the first season. In subsequent seasons erosion rates were dependent on grazing management. With moderate grazing, leaving the soil well covered with grass, erosion rates were reduced to less than those under brush. Overgrazing resulted in erosion rates on the treated watersheds remaining higher than rates under brush. Figure 2 shows erosion rates at Ono, where a good grass stand was established three

seasons after the brush was burned. The grass has been maintained in good condition since that time. Erosion is plotted as a function of runoff since it is running water that moves the soil. The erosion rates for the last three seasons of record were lower at the treated watersheds than at the brush covered watersheds, despite the greater runoff from the treated watersheds. Total erosion at Ono during this prolonged conversion period was equivalent to .05 inches depth, about the thickness of a penny. The greatest soil loss in a single year at any of the treated watersheds was equivalent to .03 inches. Such a low rate of accelerated erosion means little to the landowner. This soil loss is important because it contributes to sedimentation in rivers and reservoirs downstream.

No appreciable increases in flood peaks have been noted following the conversion from brush to grass. Runoff occurs earlier and later in the season, with more prolonged flows following a storm. This is undoubtedly related to the reduced use of water by grass compared to brush.

Summary and Conclusions

The area covered by wild woody vegetation in California, exclusive of commercial timber, has been estimated at 18 to 45 million acres. The lower estimates do not include sagebrush and other desert shrubs of the interior drainages, or brushy areas in commercial timber zones. Areas suitable for range improvement through brush removal have been estimated at between nine and ten million acres (3) in the foothill ranges of the North and Central Coast and Central Valley areas. Additional areas where brushland management may be considered for watershed improvement have not been well defined. Another ten million acres may be in this category.

Hydrologic studies by the Department of Irrigation have indicated that water yields may be increased by converting from brushland to grassland in foothill areas north of the Tehachapis. This increase has ranged from about one inch to

more than three inches, with a mean value of about two inches. Flood peaks have not been increased appreciably by this conversion. The most critical problem we have found is to establish and maintain a good grass cover to retard erosion on converted brushland. Grass can be a better erosion-control cover than brush, but it is more susceptible to deterioration under poor management.

Applying a two inch runoff increase to an estimated nine million acres of brush range suitable for improvement would result in a gain of 1.5 million acre-feet in the annual runoff from these rangelands. Since much of this gain would be in the water-surplus areas of the North Coastal and Sacramento River drainages it cannot be valued very highly. Perhaps $2 an acre foot, or $.17 per acre per year would be a fair price for this increased runoff from improved ranges. If this great an increase in water yield can be obtained from an equal area of brushy watersheds not suitable for grazing, an additional 1.5 million acre-feet might be obtained in water-deficient areas. Here the water might be valued at more than one dollar per acre-inch. This would support an average cost of two dollars per acre per year for the brushland conversion and subsequent management.

In many cases range management and watershed management will prove to be complementary. Good range management requires that when brush is destroyed, prompt revegetation with grass will be accomplished and moderate grazing will be practiced to maintain good forage production and discourage brush regrowth. The same vegetation management program will result in minimum erosion and maximum water yields. Where brushlands are managed principally as watersheds, some moderate grazing may be practiced to help pay conversion costs. The dual crop of forage and water may support good vegetation management on lands that would prove marginal if managed exclusively either for forage or for water yield.

Literature Cited

1. Burgy, R. H. Water yields as influenced by vegetation management below snowline. Intersociety Conference on Irrigation and Drainage. April 29, 1957.

2. California Forest and Range Experiment Station, Forest Service, U.S.D.A. Forest research in Callifornia. Annual Report, 1954, p. 51.

3. Sampson, A. W., and Burcham, L. T. Costs and returns of controlled brush burning for range improvement in Northern California. California Division of Forestry, Range Improvement Studies, Number 1.

4. Veihmeyer, F. J. Runoff, erosion, and soil moisture from vegetated and burned plots in typical brush areas of California. In: What we know about brushland management in California. Calif. Agric. Ext. Ser. Mimeo. Sept. 30, 1949.

Figure 1. Runoff Double Mass Curves

Ono Watersheds

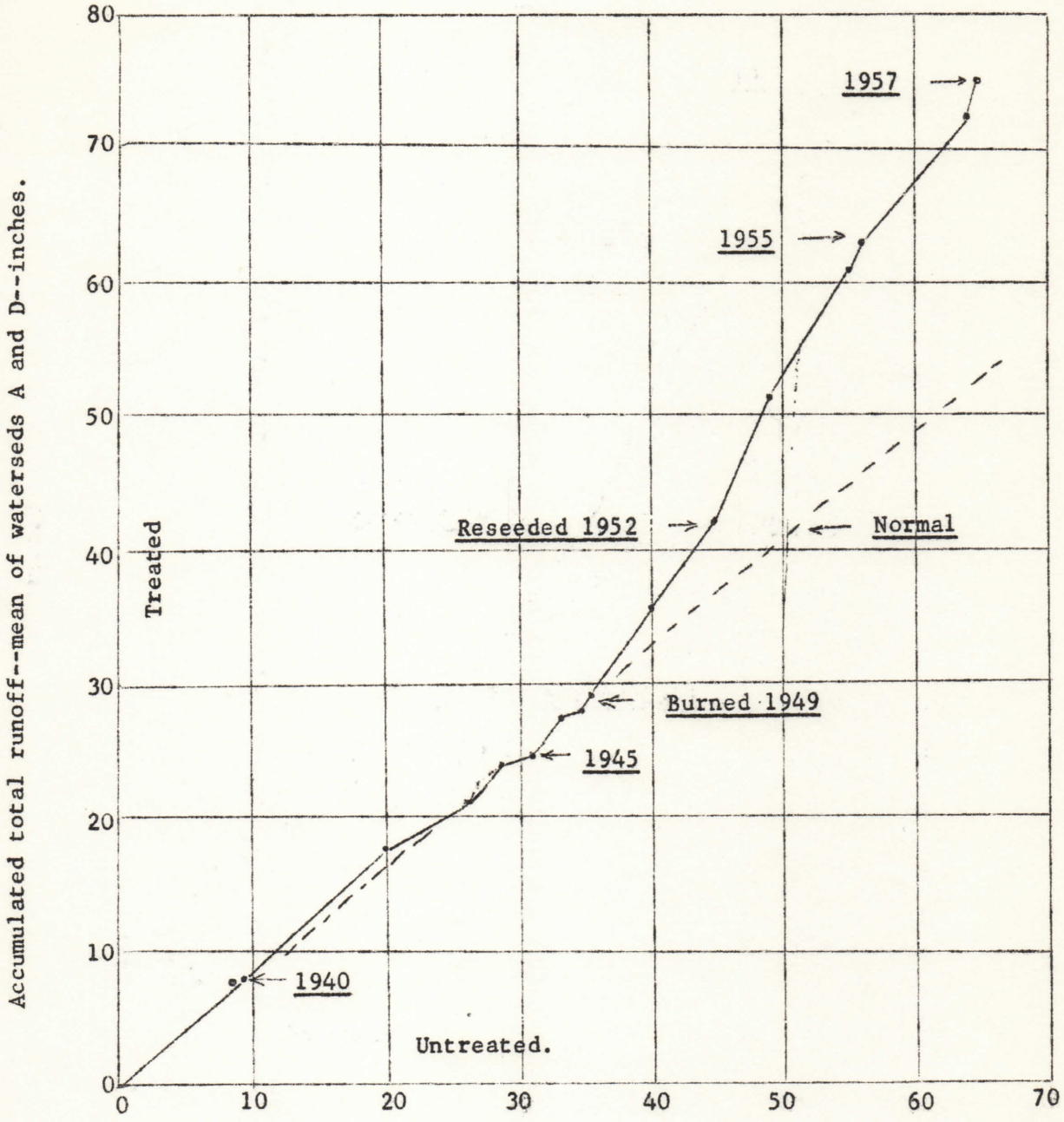
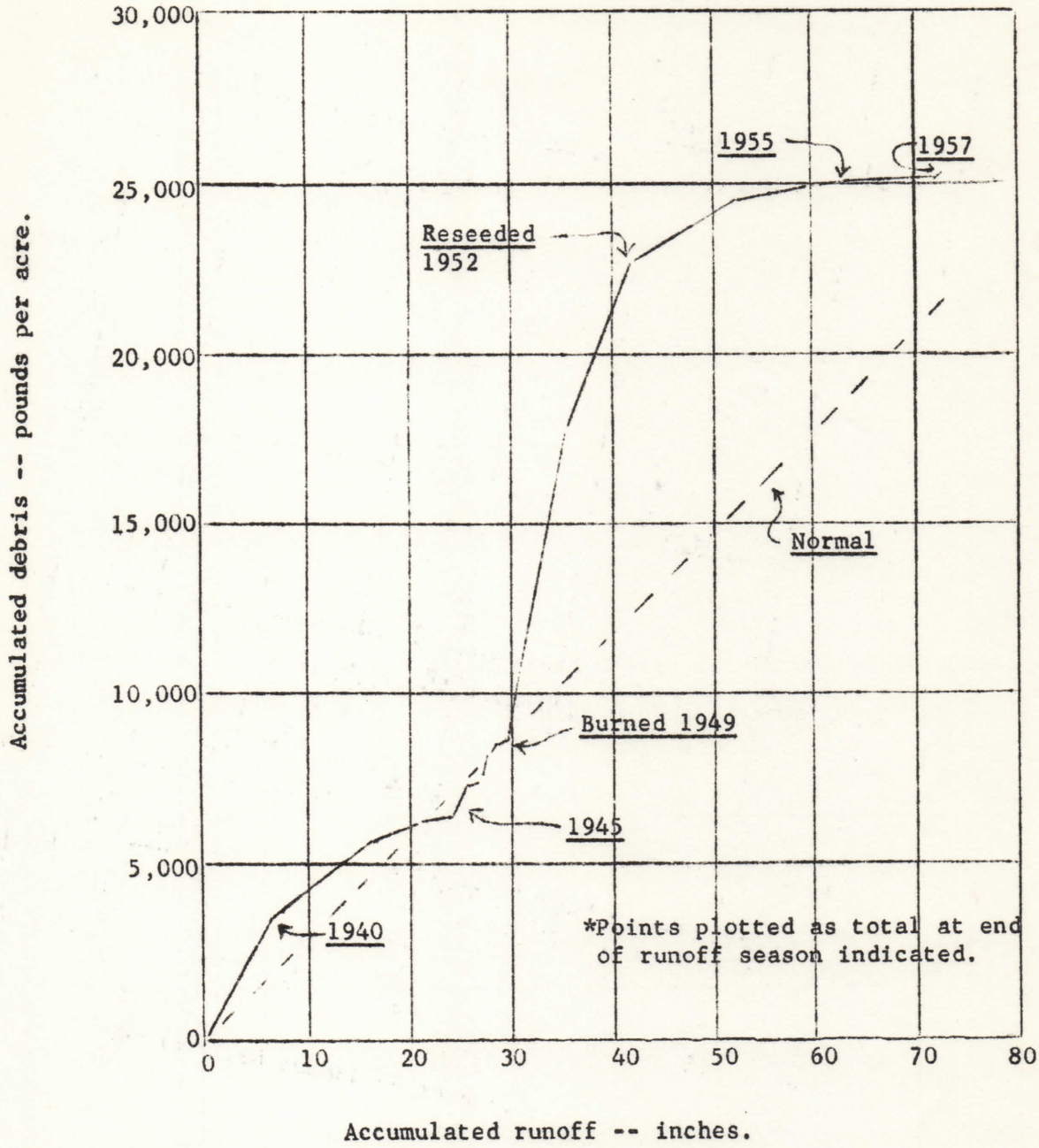
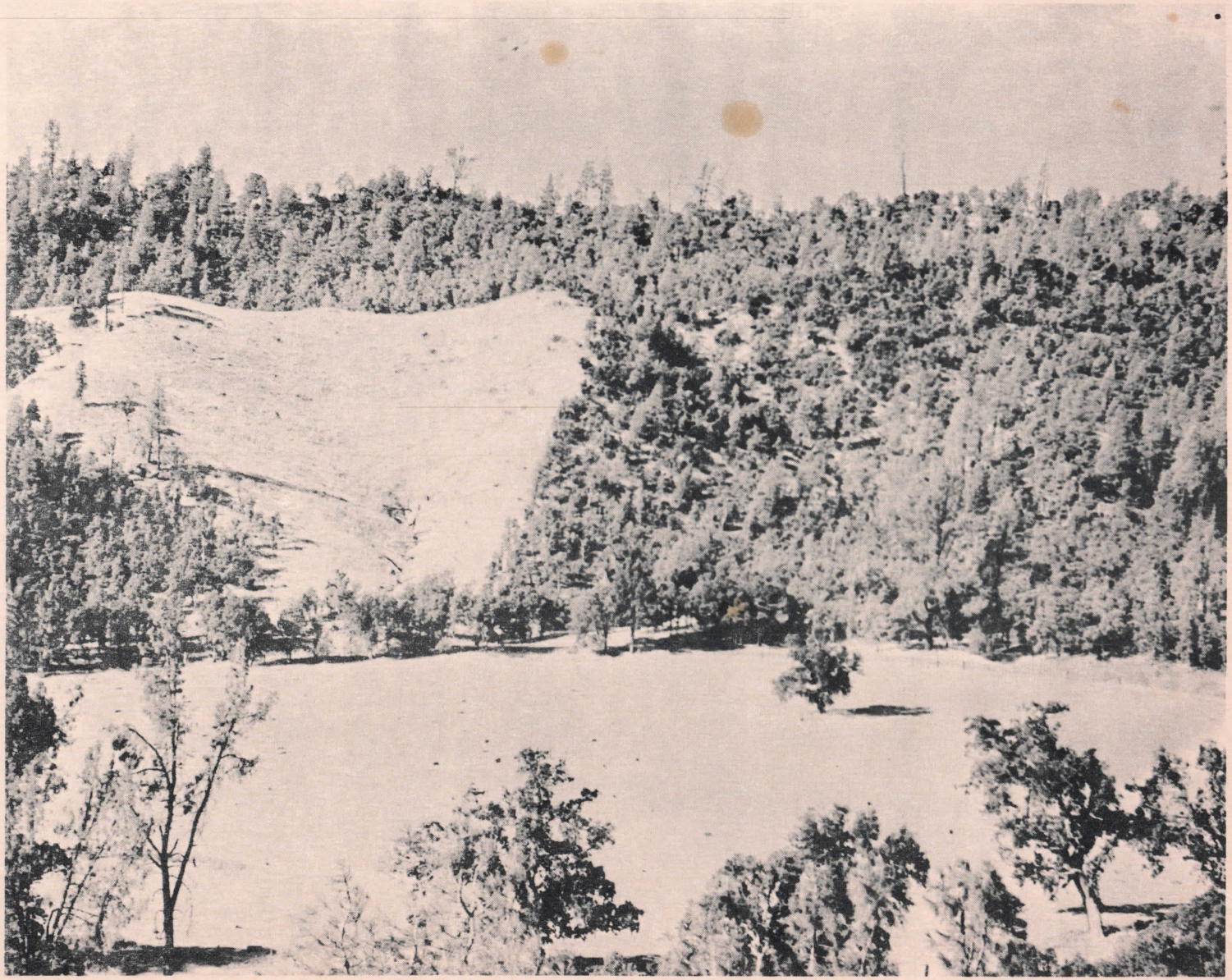


Figure 2. Accumulated debris vs. accumulated runoff

Treated Ono Watersheds





Diamond Range Watersheds - Treated unit shown 3 years after burning and reseeding