Pacific Southwest Forest and Range
Experiment Station - Berkeley, California
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THE COST OF CONVERTING BRUSH COVER TO GRASS FOR INCREASED WATER YIELD

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ABSTRACT: Gains in water yield have shown up at the San Dimas Experimental Forest in southern California after conversion of deep-rooted brush to a shallow-rooted grass in a canyon bottom and on side slopes. This paper describes the conversion program and reports treatment costs. The cost of expected gains in water yield was not competitive with today's cost for water from other sources. Costs of getting more water can be reduced, and the conversion program fitted into multiple-use management.

Wildland managers in southern California can squeeze more water from their watersheds. Research at the San Dimas Experimental Forest is beginning to show how it can be done by converting brush to grass in the canyon bottom and side slopes.

Natural, deep-rooted brush is an extravagent water user. In most years it depletes moisture throughout its root zone so that little soil water percolates to groundwater.[1] When we convert from the brush to a shallow-rooted grass cover, we reduce soil moisture losses and increase percolation to groundwater. But water savings are obtained only if: (a) the areas converted have soils deeper than depth of grass root penetration (about 3-feet deep), (b) we maintain the grass in a weed-free state, and (c) rainfall is enough to replace the soil water used by the grass the preceding year.[2]

1/ Patric, J. H. Increasing water yield in southern California mountains. Amer. Water Works Assoc. 51:4. 1959.

2/ Rowe, P. B., and Reimann, L. F. Water use by brush and grass-forb vegetation. Jour. Forestry 59:3. 1961.

Canyon Bottom Management

Canyon-bottom plants have the most opportunity to waste water. Consequently, for the first water yield improvement trial, we removed 38 acres of thirsty canyon-bottom trees and brush from 875-acre Monroe Canyon (fig. 1). Cut stumps were sprayed with brush killer. Later, we resprayed to keep weed growth and sprouting stumps at a minimum. Native grasses, which had invaded the area, provided a good shallow-rooted ground cover (fig. 2).

From streamflow measurements during the first 24 months after conversion, we estimated the average increase in streamflow at 25.5 acre feet per year. The largest increases came during summer. Before treatment the stream would have dried up by early July. Had rainfall over the 2-year period remained average (27 inches) or above, the increase would probably have been greater.

Side Slope Management

Fire swept most of the watershed 26 months after we began to measure the canyon-bottom treatment. Shortly thereafter we seeded the watershed to a mixture of Wimmera ryegrass and Blando brome.[3/] We cleared brush not completely consumed by the fire from a 140-acre block of soils deeper than 3 feet on the side slopes, and piled and burned it (figs. 3, 4). We aerial sprayed this area with brush killer the first and second year after seeding to maintain it weed- and sprout-free.[4/] It is too early to measure the effects of this treatment on streamflow. However, we expect an annual increase of about 17 acre feet. This estimate is based on water savings reported by Rowe and Reimann.[5/]

We have produced more water by converting watershed vegetation. Gains have already shown up in the canyon bottom zone and we expect additional gains as a result of the side-slope treatment. Will the gains be worth the cost?

Cost of Treatments

The total conversion costs to date are about $770 per acre for the pre-fire canyon bottom treatment and $178 per acre for the post-fire side-slope treatment (tables 1, 2). We expect to spend about $310 per year to maintain the watershed in its managed condition ($50 per year for the canyon bottom, and $260 per year for the side-slopes). Though canyon-bottom conversion has cost about four times as much per acre as side-slope conversion, we expect the largest gains in water yield from the canyon bottom. Thus, the cost per acre foot of gain from this area, in the long

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3/ Sown at a rate of 10 pounds to the acre--8 pounds of Wimmera, and 2 pounds of Blando.

4/ A mixture of 2 gallons of 2,4-D; 2 gallons of 2,4,5-T; mixed in 1 gallon of diesel oil and 98 gallons of water, applied at the rate of 6 pounds acid equivalent per acre.

5/ Op. cit.

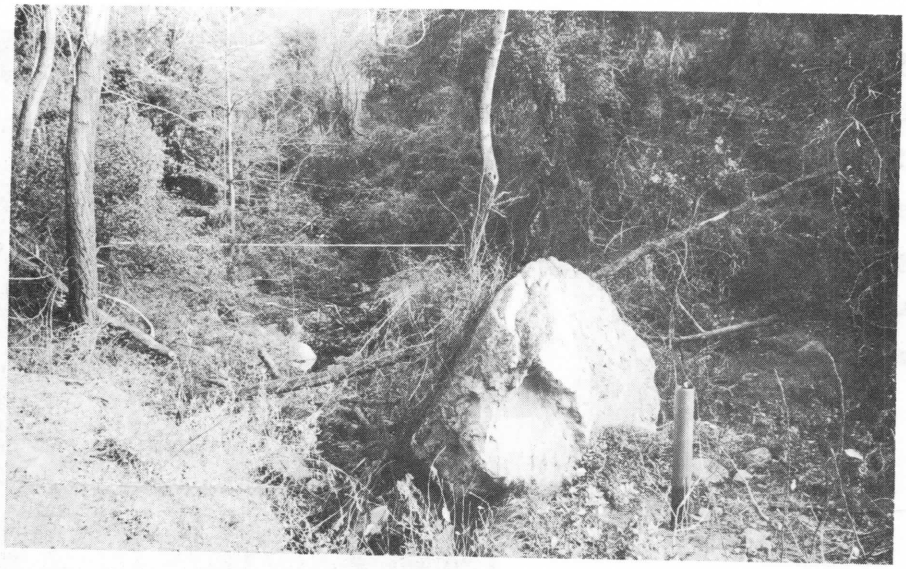

Figure 1.--Canyon-bottom zone in Monroe Canyon before removing the water using vegetation. The dominant overstory vegetation was alder, oak, sycamore, and maple. Brush species appeared in the understory.

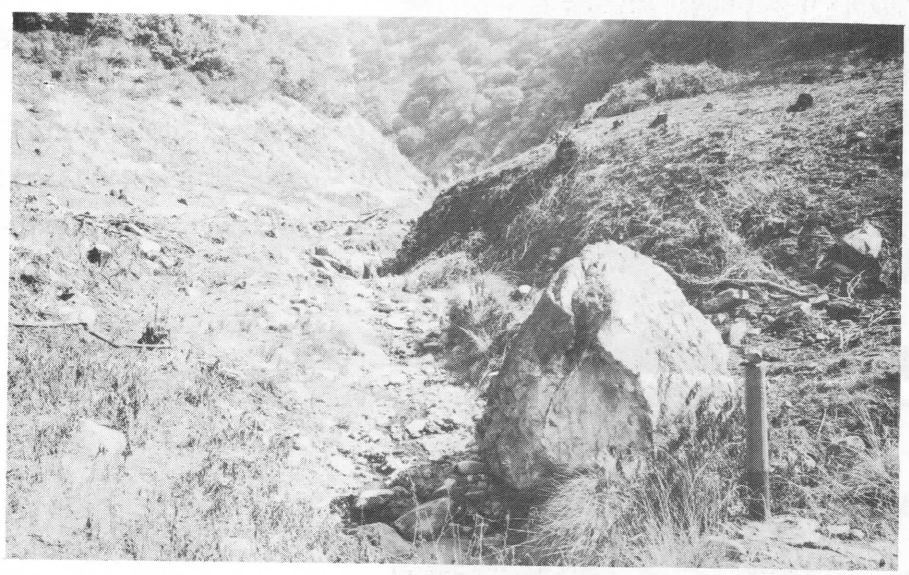

Figure 2.--Canyon-bottom zone in Monroe Canyon one year after removing vegetation. A shallow-rooted grass cover has invaded the area to give good soil protection.

Figure 3.--A brush-covered, deep-soil side slope in Monroe Canyon one year after the fire and the first aerial spraying. Species included scrub oak, toyon, chamise, and manzanita.

Figure 4.--A side-slope area after converting to grass. Brush is shown windrowed for burning. The aerially-seeded grass gives good soil protection. Very little soil movement occurred on this area during the 1961 and 1962 winter rainy seasons.

run, will be the least (table 3). In some watersheds, canyon-bottom conversion may well be profitable, and converting side-slope areas may not.

Nearly all water which is now available to southern Californians is "spoken for." The next source is Feather River water which is expected to be delivered to southern California by 1970. This water will cost about $70 or more an acre foot. The $68 to $100 cost per acre foot of water yield gained through brush conversion is competitive with this cost, but not competitive with current local water costs. However, these costs of water obtained by conversion are predicated on water yield increases in two consecutive below-average rainfall years. Lower costs may result if greater water yields are obtained when rainfall is average or above.

The only practical way to get additional water in many water-shortage areas is to improve local water yield. Though this conversion to increase local water yield was expensive, the wildland manager may not have this high a cost for conversion in areas of gentle topography, for example, or where wildfire has completely removed brush from canyon-bottoms and side-slopes. He could begin a management program to increase water yield during the period of rehabilitation by sowing and maintaining shallow-rooted grasses on burned-over, deep-soil side slopes, and canyon bottoms. In some areas, prescribed burning to rid potential water-producing areas of vegetation may also be a possibility, but higher investment costs may result.

Other benefits can stem from a brush conversion program. Intermittent streams can be made perennial, and at the same time made safely accessible for fishermen, picnickers, and hikers. Brush fields broken up by blocks of grass can be designed as fuel-breaks, and the "edge effect" improves the habitat for small game. The wildland manager will recognize this as multiple use of his watersheds. Not only may he get more water from his watersheds, but forest users get something more, too.

Table 1.--Cost of treatment to increase water yield in a 38-acre canyon-bottom zone, Monroe Canyon

Item	Road construction	Logging	Slash removal	Chemical treatment: Stumps	Chemical treatment: Brush	Total
	Dollars					
Brush killer	--	--	--	160	470	630
Equipment	430	1,900	290	80	550	3,250
Mileage	90	710	850	--	120	1,770
Labor and supervision	770	2,950	17,040	360	2,330	23,450
Total	1,290	5,560	18,180	600	3,470	29,100
Total/Acre	34	146	480	16	91	776

Table 2.--Cost of treatment to increase water yield from a 140-acre side-slope zone, Monroe Canyon

Item	Total cost		Cost per acre	
	- - - - Dollars - - - -			
Seeding				
Grass seed	330		2.35	
Helicopter	110		.79	
Labor and supervision	60		.43	
		500		3.57
Chemical control of brush				
Brush killer	1,450		10.36	
Helicopter	700		5.00	
Labor and supervision	570		4.07	
		2,720		19.43
Brush removal (cut, pile, burn)				
Equipment	460		3.29	
Labor and supervision	21,250		151.79	
		21,710		155.08
Total		24,930		178.08

Table 3.--Cost of water yield gains in Monroe Canyon

Zone of management	Initial investment	Average annual maintenance cost	Annual cost of investment (amortized at 4% for 30 years) and annual cost[1]	Expected annual gain in water yield[2]	Cost per acre foot of gain
	- - - - - - - - Dollars - - - - - - - -			Acre ft.	Dollars
Canyon-bottom	29,100	50	1,734	25.5	68
Side-slopes	24,930	260	1,702	17.0	100
Canyon-bottom plus side-slopes	54,030	310	3,436	42.5	81

[1] Amortized because (1) the value of the increase in yield may diminish through time (because water from other sources may be as cheap or cheaper in future years), or (2) we assume an entrepreneur will want to retire his investment over a reasonable period of time.

[2] These gains in yield represent raw water delivered at the mouth of the canyon. Additional costs will be incurred to distribute, store, and treat the water for potential consumer use.

ACKNOWLEDGMENT

The San Dimas Experimental Forest is maintained by the Forest Service, U.S. Department of Agriculture in cooperation with the California Division of Forestry. Since 1947 this has been a joint research project with the California Division of Forestry, which participates in program planning and provides financial support. Other long-term cooperators are the Los Angeles County Flood Control District, the Los Angeles County Fire Department, and the University of California, which provide staff or other support or use research facilities at the experimental forest.

Special recognition is due these agencies and the California Department of Water Resources for assistance with emergency rehabilitation work after a wildfire in July 1960. Their cooperation made it possible to restore experimental facilities and start emergency research on methods of managing chaparral watersheds for more effective control of fires, floods and erosion, and water yield.

NOTICE: A uniform system of naming report series has been adopted for Forest Service Experiment Stations. Beginning January 1, 1963, research documents published by the Forest Service will be in one of these three series:

1. A numbered series, U.S. Forest Service Research Papers.
2. A numbered series, U.S. Forest Service Research Notes.
3. A numbered series, U.S. Forest Service Resource Reports.

The publishing unit will be identified by letters before the number, and the numbers will be consecutive in the order of publication dates. For example, this Station's first Note in 1963 is designated U.S. Forest Service Research Note PSW-1. Certain miscellaneous material, such as annual reports and experimental forest guides, will continue to be issued as unnumbered, non-serial publications.

The Research Note series formerly published by this Station closed with the release of Research Note No. 211, 1962.

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