THE
SAN DIMAS
EXPERIMENTAL FOREST
By
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Approved:
Professor of Forestry
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INTRODUCTION

The yield of useable water from the chaparral covered mountains of Southern California is of vital importance to the rural and urban populations that occupy the valleys adjacent to these watershed areas. During the past half century domestic, industrial and agricultural demands for water in this semi-arid region have reached a point far in excess of the normal supply, as is indicated by declining water tables in the valley basements. Once you could get artesian water by drilling wells thirty to forty feet deep; now you must go down 150 to 500 feet. These valley basins are natural storage basins for the excess water coming off of the mountainous areas.

The problem of providing an adequate amount of useable water to meet present and future needs is made very difficult by the excess of demand over local supply. This deficiency in the local supply has led to the expenditures of huge sums of money in bringing water great distances from other regions. Rains are confined almost entirely to the winter season and frequently occur as torrential downpours for which it is difficult to provide sufficient storage by engineering means. Unless the rainfall is stored it is wasted to the sea; lost for use as well as creating in transit a very serious hazard to life and property.

These torrential downpours make the problem of controlling soil erosion of paramount importance. The
erosion not only renders worthless for many years the ground on which it is taking place, but of greater importance renders the water supplied by the storms un-useable for human consumption. Erosion also results in the silting of storage and flood control reservoirs, in the clogging of gravels in water spreading grounds, and adds much to the danger inherent in floods. Erosion does not occur to any extent when the ground is covered with its natural cover of chaparral, but may be a result of either burning of the vegetation on the watersheds or of soil disturbance by such a cause as road construction.

It is recognized that the existing chaparral vegetation has an important influence in reducing the magnitude of floods and erosion. At the same time this vegetation takes its toll in consumption of water. This leads to the problem of increasing the yield of useable water by some method of systematic management of the watershed vegetation consistent with the control of floods and erosion.

The watersheds of the San Gabrial, San Bernardino, and San Jacinto ranges furnish most of the local water available to Southern California. Since these areas occur largely within National Forests, their management for maximum productivity is of concern to the United States Forest Service. A comprehensive investigation of problems in watershed management in the chaparral region has been initiated by the California Forest and Range Experiment Station. A large part of the work is
being concentrated in the San Dimas Experimental Forest which has been specially set aside for that purpose.

THE EXPERIMENTAL AREA

History of Area:

Approximately the eastern one-half of the San Dimas Experimental Forest was included in the burn of the San Gabrial Fire of 1919, which burned over approximately 500,000 acres. The western one-half of the Forest has not been burned over in a great many years.

With the view of replanting the San Gabrial burn, the Los Angeles County Forestry Department established an experimental nursery in 1920 at Tanbark Flats, the present site of the field headquarters of the experimental forest. Areas estimated to total 500 acres in extent were planted to coniferous trees. Trees planted in the areas near Tanbark Flats include Coulter pine (Pinus coulteri), Knobcone pine (Pinus attenuata), Scotch pine (Pinus sylvestris), Indian longleaf pine (Pinus longifolia), Western yellow pine (Pinus ponderosa), Deodar cedar (Cedrus deodara), and others. From a high point these trees may be seen scattered in small groups around Tanbark Flats.

In 1930-31 the Los Angeles County Flood Control Dams were built near the mouths of Big Dalton and San Dimas drainages. These two large dams are major controls in the experimental setup.
The Forest was tenatively laid out in 1932 and construction started in 1933.

The preliminary planning and initiation of work on the Experimental Forest was done under the leadership of Dr. W. C. Lowdermilk, who left the Forest Service in 1933 to become Vice-Director of the Soil Conservation Service. Mr. E. N. Munns, now of the Washington Office of the Forest Service, who began studies in forest influence in Southern California 26 years ago, has contributed much in shaping the present watershed research program. The project, particularly the development and protection of the San Dimas Experimental Forest is being carried on in close cooperation with the Administrative Divisions of the Forest Service through the Supervisor of the Angeles National Forest. The dams and other major engineering features have been designed and built under the supervision of the Regional Engineer from the office of the Regional Forester.

Location:

The San Dimas Experimental Forest is situated in the Sierra Madre Mountains northeast of Glendora, California, within the boundaries of the Angeles National Forest. It has an area of approximately 17,000 acres, including the drainage basins of Big Dalton and San Dimas Canyons tributary to the San Gabriel Valley.

Purpose:

The investigations to be conducted on the Forest
have, in general, a two-fold purpose: first, to make a quantitative determination of the relation of chaparral vegetation to the yield of useable water from mountain watersheds and its function in reducing erosion; second, to develop methods of management or treatment of the vegetation in order to obtain a maximum yield of useable water with a minimum amount of erosion.

The information required for the solution of these problems is as follows:

1. Exact measurement of precipitation on mountain drainage basins.

2. Measurement of yield of water and debris from typical watersheds with varying types of vegetation and covers.

3. Analysis of the types of vegetation involved in water losses and control of erosion on mountain watersheds.

4. Determination of the consumption of water by native vegetation and by types of vegetation which might be substituted for the native chaparral.

5. Quantitative determination of the environmental factors affecting water use by vegetation.

These problems are being attacked by a system of studies in which vegetation water relationships are investigated in progressive degrees of intensity. The experiments and units involved are:

The Experimental Units:

1. Major and Intermediate Watersheds:
To measure the summed effect of all environmental factors on rainfall-run-off and erosion relationships. The major watersheds consist of the whole San Dimas and Big Dalton drainages, which are sub-divided into ten intermediate compartment watersheds, ranging in area from one to fourteen square miles.

Rainfall on these watersheds is measured very accurately by rain gauges spaced one-half mile apart mainly on a system of trails located on contours at elevations of 2100, 3100, 4100, and 5100 feet. The rain in these rain gauges, some 370 in number, is measured at the end of each storm. Measurement is made by weighing the entire rain gauge on a spring balance graduated directly in inches of rain. It takes ten two-man crews a full day to do the job.

Records of the rate of rainfall are obtained by fifteen intensity rain gauges spaced one-half mile apart mainly on a system of trails located on contours at elevations of 2100, 3100, 4100, and 5100 feet. These intensity rain gauges are of the tipping bucket type and automatically record by electrical impulse on moving charts located in the instrument room at Tanbark Flats. These gauges are distributed throughout the area as equally as possible, both by altitude and by intermediate watersheds.

Stream flow resulting from the rainfall is measured at the mouth of each of the ten intermediate watersheds.
Flood flows are measured by means of Parshall flumes, and ordinary flows by means of ninety degree V-notch weirs. These Parshall flumes range in throat-width from eight to thirty feet, in capacity from 250 to 3520 second feet of water. The modified Parshall flume on the main fork of San Dimas canyon is one of the largest of its kind in the world.

All of the stream guaging stations are equipped with automatic time stage recorders and electric depth gauges. This electric depth gauge is a device developed by the scientists of the experimental forest. Briefly it consists of a plumb line in the form of a steel measuring tape. This is dropped into the water through a hole in the floor of the instrument house and when the plumb weight strikes the surface the contact closes an electrical circuit and actuates a millimeter needle in the instrument. Knowing the depth of the flume, it is a simple matter to figure the height of the water.

The sum of all these stream guaging stations will give the total stream flow from the experimental area, which may be checked by reservoir records at the Los Angeles County Flood Control Dams near the mouth of the Big Dalton and San Dimas drainages.

Surveys have been made of the Big Dalton and San Dimas reservoirs. Periodic re-surveys will show the amount of debris deposited in them as the result of erosion on the major areas.
2. Small Watersheds:

A group of small watersheds of similar environmental characteristics, in which the factor of vegetation is isolated by treatment. It is planned to leave one watershed with its present vegetation undisturbed; and to burn the other two, keeping one denuded by repeated burning and allowing the other to return to normal plant cover after the single burning. The difference in the yield of water and debris between burned and unburned watersheds should evaluate the effect of vegetation on these two watershed products.

There are two sets of small watersheds on the Forest: one (Bell Canyon) at elevations between 2500 and 3400 feet; and the other (Fern Canyon) between elevations of 4500 and 5400 feet.

These small watersheds are equipped with much more elaborate and intensive means of measuring rainfall, run-off and erosion than have been provided in the intermediate watersheds.

Bell Canyon has four watersheds ranging from 37 to 101 acres in area, Fern Canyon three watersheds ranging from 35 to 53 acres. Each of these watersheds is blocked by an Ambursen-earth fill type dam with a 3 foot control flume and a ninety-degree V-notch weir above the reservoir for measuring the run-off. The reservoirs are lined with gunite - a sprayed cement - and marked off in one-foot contours and two foot transverse ribs. Thus it is
possible quickly to measure the debris upon draining off the water after each storm.

3. Run-off and Erosion Plots:

Miniature areas on which are measured precipitation and surface run-off from small segments of a watershed under denuded and normally vegetated conditions. The purpose of these plots is to investigate the influence of vegetation on surface run-off and erosion. At present, the Forest contains three sets of plots located at elevations of 1500, 2700, and 5000 feet and containing vegetation typical of these altitudes. One installation consists of four one-fortieth acre plots, two with normal chaparral cover, and two kept denuded by burning. The other two sets, totalling 18 plots, contain three groups each of three plots: one group to be kept with normal cover, one continuously denuded, and one denuded and then allowed to return to natural chaparral cover. The latter sets of plots are now being calibrated during an initial period of several years before treatment of the vegetative cover is started.

The set of plots located at Tanbark Flats are 10 feet wide by 108.9 feet long and contain one-fortieth of an acre. They are located on a $25\%$ slope. To keep the run-off of one plot from leaving that plot, the plots are fenced with tin strips driven into the soil. A tin gutter at the lower end of the plot catches the run-off and eroded material.
The run-off and erosion from each plot is measured as follows. The water and eroded material from the trough at the lower end of the plot is run into a concrete settling tank where the eroded material settles out. The clear water from the settling tank then runs through a specially designed tipping bucket which catches one-tenth cubic foot of water, then dumps it and brings another bucket into position. Each movement of the bucket on each plot is recorded electrically on a moving strip chart synchronously with a record of the rainfall. Water from the tipping bucket then goes to a total collector tank as a check. Later inspection of the chart permits a comparison of the rate of run-off from the denuded, succession and natural plots in relation to rainfall.

4. Road-Fill Erosion Control Plots:

A series of rectangular areas on a road fill, bounded by border strip, on which are tested various methods of controlling erosion from fill slopes. Eroded material is caught and measured in bins at the foot of each plot. On the Experimental Forest there is one set of seven road fill plots, each one-fiftieth acre in area, at the head of Volfe Canyon. On these are studied the efficiency of erosion control methods such as brush wattles of varying design, in conjunction with sowing of grains and plantings of cuttings of sprouting species as well as spreading the surface with hay.
5. Firebreak Succulent Plots:
Six plots, covering a range of elevations from 1500 to 5000 feet, have been established within the Experimental Forest for the study of succulent plants of low inflammability suitable for planting on firebreaks. The purpose of this study is to determine the feasibility of establishing a fire resistant cover, thereby reducing maintenance costs, ugliness, and erosion from these normally denuded strips. In each plot, which is fenced to keep out rabbits and larger animals, are planted twelve different species of succulents which might be suitable for firebreak planting; and a study is being made of their relative values, based on survival, rate of growth, and other criteria. Included in these twelve species are such plants as ice plant, sea fig, and euphorbia. Evidently none of the twelve species being tried are suitable for such a use as they were all killed last year by freezing.

Some work is now being done with using arsenic compounds to sterilize the soil. If these tests prove successful they will solve the maintenance cost problem, but will do nothing towards the ugliness and erosion problems.

6. Lysimeters:
Impervious concrete or metal tanks of various dimensions which when filled with soil, are used to grow plants varying in size from grass up to trees. Their
purpose is to determine the relative rates of water consumption by transpiration of various plant species, and the effect of these species on rates of water percolation through the soil. There are five different types of lysimeters to be used at the installation near Tanbark Flats: the large-sized, the unconfined, the medium-sized, the small-sized, and the root study lysimeters.

The large lysimeters are 26 in number, each having surface dimensions of 10.5 by 21 feet and a depth of six feet, and are for the purpose of studying the water cycle with large masses of soil and vegetation and using longer growth rotations.

These large lysimeters are built to last at least 50 years. They are constructed of concrete and, to eliminate the possibility of the concrete having any chemical effect on the growing plants, the insides have been painted with bakelite enamel. They are built with a 5% slope with the highest end being to the north.

At present the lysimeters are filled with soil and are waiting for complete settlement to take place. A one foot overburden of soil has been placed on the tanks to allow for settlement which may take 1 or 2 years.

Mixed soil was used to fill the lysimeters instead of trying to stimulate the soil in place of the surrounding areas. This was done for the following reasons:

a- It would be impossible to get the soil in a truly natural condition in any feasible length of time.
b- It was desired to control all possible factors so that the only variable would be the plants themselves.

c- The results obtained from the lysimeters will not be directly applied to the surrounding area, but only comparative results will be applied.

The mixed soil that went into the lysimeters was obtained by mixing the soil taken out in the excavation for the tanks. The mixing was accomplished in the following manner. Excavation was done by hand and was going on at various depths simultaneously. Excavated material was brought from these various depths and dumped, a wheelbarrow load at a time, into a pile thus accomplishing a rough mixing. The material from the pile was run through a concrete mixer to further mix it and to break up clods. After being screened through a \( \frac{3}{4} \) inch mesh it was again mixed in the concrete mixer and stored under cover until the concrete tanks were ready to be filled.

The tanks were filled about a year ago. After trying several methods of tamping; such as, tamping with a wedge shaped tamp, wetting each layer down and chopping with a spade, lowering soil carefully into tank and not tamping, dropping into tank and not tamping; it was found that the most uniform soil density was obtained by putting the soil in in 3 inch layers and chopping in with a spade. After the filling was completed the tanks were covered with a roof until the fall of 1937 when the roof was removed and replaced by excelsior covered by wire netting.
The excelsior covering keeps the soil from baking and cracking.

After settlement is complete, the overburden will be removed and the lysimeters planted to grass. They will be in grass for about 3 years depending on the uniformity of drainage and seepage. This period will be the period of calibration.

After calibration is complete the lysimeters will be planted in the following way: Five species of native vegetation have been selected to be planted. The tanks will be planted in groups of three with two or more border tanks in between, dependent on the difference in height of the species being planted next to each other. Starting at the west end of the battery of lysimeters the following species will be planted in order: wild buckwheat (*Eriogonum fasciculatum*), greasewood (*Adenostoma fasciculatum*), buck brush (*Ceanothus* species), Wislizenus oak (*Quercus wislizeni*) or scrub oak (*Quercus dumosa*), and Coulter pine (*Pinus coulteri*). The area to the north and south of the large lysimeters will be planted in the same cover as the lysimeters to a distance of 30 to 50 feet respectively.

The plants used to plant the lysimeters will be grown at the station and planted as one year transplants. They will be planted at the beginning of the rainy season and will be given no additional encouragement after being planted.

Running underneath and the full length of the battery
of large lysimeters is the collector tunnel. In the tunnel are three collector tanks for each lysimeter. The largest of these tanks is connected to the bottom of the lysimeter and collects the seepage water. Another one is connected to a trough on the surface that catches the run-off water. The last of the tanks is connected to a trough rain gauge running between two lysimeters. Measurement of the amount of water in the tanks is recorded electrically in the instrument room at Tanbark Flats. Other measurements will be taken at a major climatic station that will be established in conjunction with the large lysimeters.

To determine whether the impervious confining walls of the large lysimeters have any unnormal effects on the water relationships, two so-called unconfined lysimeters have been built. These are not in reality lysimeters in the true sense of the word. In preparing these unconfined lysimeters excavations were made the same size as the tanks of the large lysimeters and then filled with the same kind of soil as was used to fill the large lysimeters. The unconfined lysimeters will be planted and treated in the same way as the large lysimeters.

Measurements on the unconfined lysimeters will consist of determining run-off and soil moisture content at various depths. Run-off will be measured by establishing a run-off plot on one of the lysimeters. Members of the staff are now working on a device to measure moisture
content by the electrical resistance of the soil between two electrical poles set in the soil.

The medium sized lysimeters are 30 circular metal tanks each having a surface area of 750 square inches and a depth of 40 inches. Each lysimeter has a capacity of 1800 pounds of soil. These lysimeters allow observations on the water cycle to be made both by weight and by volumetric measurement of percolation and run-off. The run-off and percolation waters are caught in separate tin cups. By means of a special hoist the tanks may be lifted out of the trough in which they rest to be weighed. Groups of plants will be planted in each tank to obtain data on evaporation and transpiration. Groups will be left in the tanks for ten year intervals.

The small sized lysimeters are 72 circular metal tanks each with a surface area of 250 square inches and 20 inches deep. Each lysimeter has a capacity of 300 pounds of soil. The only measurements taken will be taken by weighing the lysimeters with the use of the same hoist as is used to weigh the medium sized lysimeters. One plant will be planted in each small lysimeter and studies made of transpiration, evaporation, and wilting point. They will not be operated under normal rainfall, but will be watered. Individual plants will be left in a lysimeter for 5 years.

The study lysimeters are to be 5 in number and will each be 6 feet by 4 feet and 5 feet deep. Three sides and the bottom will be of concrete while the fourth side will
be of boards. Each lysimeter will be planted to one of the species to be planted in the large lysimeters. After a certain length of time the board sides will be removed, the soil washed out and the root structure of the plants studied.

The entire lysimeter installation is surrounded by a rodent proof fence high enough to keep deer out. The rodent proof fence is constructed in the following way: Hardware cloth of \( \frac{1}{2} \) inch mesh has been put into the ground to a depth of three feet and then turned out at right angles for another two feet. The hardware cloth also extends three feet above ground where it is attached to a 16 inch convex strip of galvanized iron. Above the galvanized iron strip extends woven wire for another three feet. All rodent life within the lysimeter area will be killed when the lysimeters are put into operation.

7. Climatic Stations:

The Forest contains four complete stations located at elevations of 1500, 2700, 4350, and 5100 feet. These possess the following instruments for measuring climatic and soil environmental factors: air hygrothermograph, soil thermograph, air and soil thermometers, psychrometers, anemometer, wind direction transmitter, evaporation pans and atmometers. Two stations, less elaborately equipped, are located in Bell Canyon watershed No. 2 and No. 4 at 2800 feet elevation. The latter is planned to measure environmental influence before and
after the watershed is burned, while the former is to serve as a check. Installation of several more stations is contemplated to complete the range from the valley floor to timberline.

8. Ecological Studies:

A detailed type map is being made of the existing vegetation in each watershed, together with a statistical analysis of each vegetation type to depict its species composition and cover density. Phenological observations are carried on continuously at 14 carefully selected typical stations. To determine the biological factors affecting the water cycle, a study is being made also of the fauna of the Experimental Forest.

9. Geological and Soils Studies:

To complete the picture of environmental influences, surveys are being made of the geology of the Forest and of its soil types.

10. Flora, Fauna and Geological Collections:

In conjunction with the work being carried on, more or less complete collections of the plants, birds, reptiles, mammals, rocks and minerals, and insects of the Experimental Forest area has been made. Mr. Wright, taxidermist; Mr. Horton, botanist; and Mr. Story, geologist, were in charge of making these collections.

Personnel:

The work is supervised by the California Forest and Range Experiment Station with headquarters at Berkeley,
where Dr. E. I. Kotok is in charge. A part of the station project in forest influences, directed by C. J. Kraebel, is administered from offices in Glendora under the immediate control of J. D. Sinclair, silviculturalist in charge of the San Dimas Experimental Forest, and his assistant Dr. H. G. Wilm. Mr. Hamilton is in charge of climatic stations; Mr. E. Coleman is in charge of planting the lysimeters; and Mr. Curry, Mr. Moore, and Mr. Braman are civil engineers in charge of construction.

Construction was made possible through the aid of the Civilian Conservation Corps, the Works Progress Administration and other national emergency relief agencies.

Among federal bureaus with which the project is mutually articulated are the Bureau of Agricultural Engineering, Geological Survey, Soil Conservation Service, and Weather Bureau.

Much helpful cooperation was given by many local agencies and individuals.
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   Los Angeles Times Sunday Magazine, Dec. 19, 1937

4. Personal Inspection, and Explanation of Projects with
   Mr. E. Coleman and Mr. Braman

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APPENDIX
The Head of San Dimas Canyon.
The Snow-Cap is Old Baldy.

The Head of the Big Dalton Watershed.
Note Contour Trails.
Big Dalton Reservoir and Dam built by Los Angeles County Flood Control District. This structure provides a master control for Big Dalton Canyon, a major watershed on the San Dimas area.

Stream gaging station near the mouth of the main San Dimas Canyon Watershed No. 6. A modified Parshall flume with 30-foot throat for measuring flood flows. 90° V-notch weir for measuring low flows shown at right. Measuring range 0.005 to 3520 cubic feet per second.
Bell Small Multiple Watersheds

Area burned in 1919. 71 rain gages are located on contour trails at 2500, 2800, 3100 and 3400 feet elevations. Total area 277 acres.
FERN SMALL MULTIPLE WATERSHEDS

Vegetation unburned for past 50 years. 47 rain gages are located on contour trails at 4700, 4950 and 5200-foot elevations on total area of 128 acres.
Bell Canyon Stream Guaging Station

Reservoir at the mouth of Fern Watershed No. 1, thirty-five acres. Three-foot Parshall flume for measuring flood flows and 90" V-notch weir for measuring small flows are shown in the background. One-foot contours and two-foot transverse ribs painted on the gunite lining aid in measuring debris.
## SAN DIMAS EXPERIMENTAL FOREST
### DESCRIPTIVE DATA: MAJOR, INTERMEDIATE AND SMALL WATERSHEDS

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*Los Angeles County Flood Control.
**Ambursen—earth fill.
Recording Instruments for Run-off Plots.

VoIfe Canyon Road Slope Erosion Control Experimental Plots. The effectiveness of various methods of slope fixation is under observation and the erosion from each plot measured in bins at the base of the fill.
The Battery of Large Lysimeters.

The Small Lysimeters in the Foreground.
The Medium Lysimeters in the Background.
Note the Rodent Proof Fence.
DIAGRAM OF A SINGLE LARGE LYSIMETER
SURFACE AREA 5-MILACRES (104 X 21 FEET)

1. TROUGH RAIN GAGE. 2. RAINFALL COLLECTOR TANK.
3. RUNOFF TROUGH AND COVER.
4. RUNOFF COLLECTOR TANK. 5. SEEPAGE OUTLET CHAMBER.
6. SEEPAGE COLLECTOR TANK. 7. WATER DEPTH TRANSMITTER.
8. COLLECTOR TUNNEL.
9. CONCRETE WALLS AND FLOORS.
10. VEGETATION PLANTED IN AND AROUND EACH LYSIMETER.
Climatic Station at 4350 feet altitude equipped for measurement of environmental factors of air and soil.

Note: The preceding pictures with the exception of the snapshots were taken from "The San Dimas Experimental Forest."