# THE SAN DIMAS EXPERIMENTAL FOREST

CALIFORNIA FOREST and RANGE EXPERIMENT STATION
FOREST SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

# The San Dimas Experimental Forest

*Dedicated to the Pursuit of Studies in the Management of Chaparral Watersheds for the Maximum Yield of Useful Water and for other Human Benefits*

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## I. The Problem of Watershed Management in Southern California.

The yield of usable 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 indicated by declining water tables in alluvial filled basins underlying the valley floors. These natural underground basins form an ideal system of storage and distribution of water and are normally replenished by flows from the mountain areas.

The problem of providing an adequate amount of usable water to meet present and future needs is accentuated by the excess of demand over present local supplies. This shortage has led to the importation of water from other regions at great cost, which factor limits its agricultural use. The problem is made more difficult by unequal seasonal distribution of rainfall, characteristic of the region. Rains confined almost entirely to the winter season frequently occur as torrential downpours for which it is difficult to provide sufficient storage by engineering means, and which unless stored, waste to the sea, lost for use as well as creating in transit a very serious hazard to life and property.

Accessory to the problem of flood control is that of controlling soil erosion, which as an accompaniment of excessive run-off may render the water supplied by storms unusable 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. This erosion may be a result either of burning of 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 usable water by some method of systematic management of the watershed vegetation consistent with the control of floods and erosion.

The watersheds of the San Gabriel, 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 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 influences in Southern California 25 years ago, has contributed much in shaping the present watershed research program. The project, particularly the development and protection of the San Dimas Ex-

perimental Forest, is being carried on in close co-operation 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.

## II. The Experimental Area.

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.

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 usable water from mountain watersheds and of its function in reducing erosion; second, to develop methods of management or treatment of the vegetation in order to obtain a maximum yield of usable 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 vegetative cover;
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; and

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 experimental units involved (refer table, page 12, and map, pages 10 and 11) are:

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 is measured very accurately by rain gages spaced one-half mile apart mainly on a system of trails located on contours at elevations of 2100, 3100, 4100 and 5100 feet. These rain gages, some 370 in number, are read at the end of each storm.

Records of the rate of rainfall are obtained by fifteen intensity rain gages which automatically record the rate and amount of precipitation on a chart. These gages are distributed throughout the area as equally as possible, both by altitude and by intermediate watersheds.

Streamflow resulting from the rainfall is measured at the mouth of each intermediate watershed by means of control flumes of various sizes for flood flows, and 90° V-notch weirs for ordinary flows. (See Plate, page 13.)

The sum of all these stream gaging stations will give the total streamflow from the experimental area, which may be checked by reservoir records at the Los Angeles County Flood Control Dams near the mouths of the Big Dalton and San Dimas drainages. (Plate page 13.)

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 (Plates, pages 14 and 15).

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.

A concrete dam and a concrete lined reservoir have been built at the mouth of each small watershed. These structures are to catch debris eroded from each watershed. A 3-foot control flume and a 90° V-notch weir are used to measure the run-off (Plate, page 16).

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. 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 1/40-acre

plots, two with normal chaparral cover, and two kept denuded by burning (Plate, page 17.) 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 run-off from each plot is measured by catching the water in a concrete trough at the base of the plot and running it through a specially designed tipping bucket which catches 1/10 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. 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 strips, 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 1/50 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 the sowing of grains and planting of cuttings of sprouting species as well as spreading the surface with hay (Plate, page 17).

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 deter-

mine the feasibility of establishing a fire resistant cover, thereby reducing maintenance costs 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.

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. The following lysimeter installations are being completed near Tanbark Flat:

a. A series of 50 small metal lysimeters, each with a capacity of 300 pounds of soil, for the purpose of evaluating, by weight, day by day losses due to transpiration and evaporation.

b. Thirty medium-sized metal tanks, each with a capacity of 1800 pounds of soil. These instruments allow observations on the water cycle to be made both by weight and by volumetric measurement of percolation and run-off.

c. A group of 26 large concrete lysimeters, each having surface dimensions of 10.5 by 21 feet and a depth of six feet, are for the purpose of studying the water cycle with larger masses of soil and vegetation, using longer growth rotations. Provision is being made for the measurement of both intensity and amount of rainfall, run-off and percolation. (See diagram, page 19.)

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 di-

rection transmitter, evaporation pans and atmometers (Plate, page 18). 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. Headquarters Facilities:

Since the solution of problems involved in this investigation is expected to require a period of thirty years or more, a complete field headquarters has been constructed at Tanbark Flat, in the San Dimas drainage. Permanent facilities have been set up here for the conduct of experimental work and the housing of technical personnel. These include dwellings, laboratory, garage, shop, power plant and stable (Plate, page 18). Tanbark Flat was formerly the site of an experimental nursery conducted by the Los Angeles County Forestry Department. The extensive groves of coniferous trees which were planted around that nursery now form an attractive setting for the Experimental Forest headquarters. In addition to the necessary roads and trails, communication with all parts of the Experimental Forest is provided by a telephone system connecting the headquarters with all stream-gaging stations and other major installations.

## Acknowledgments

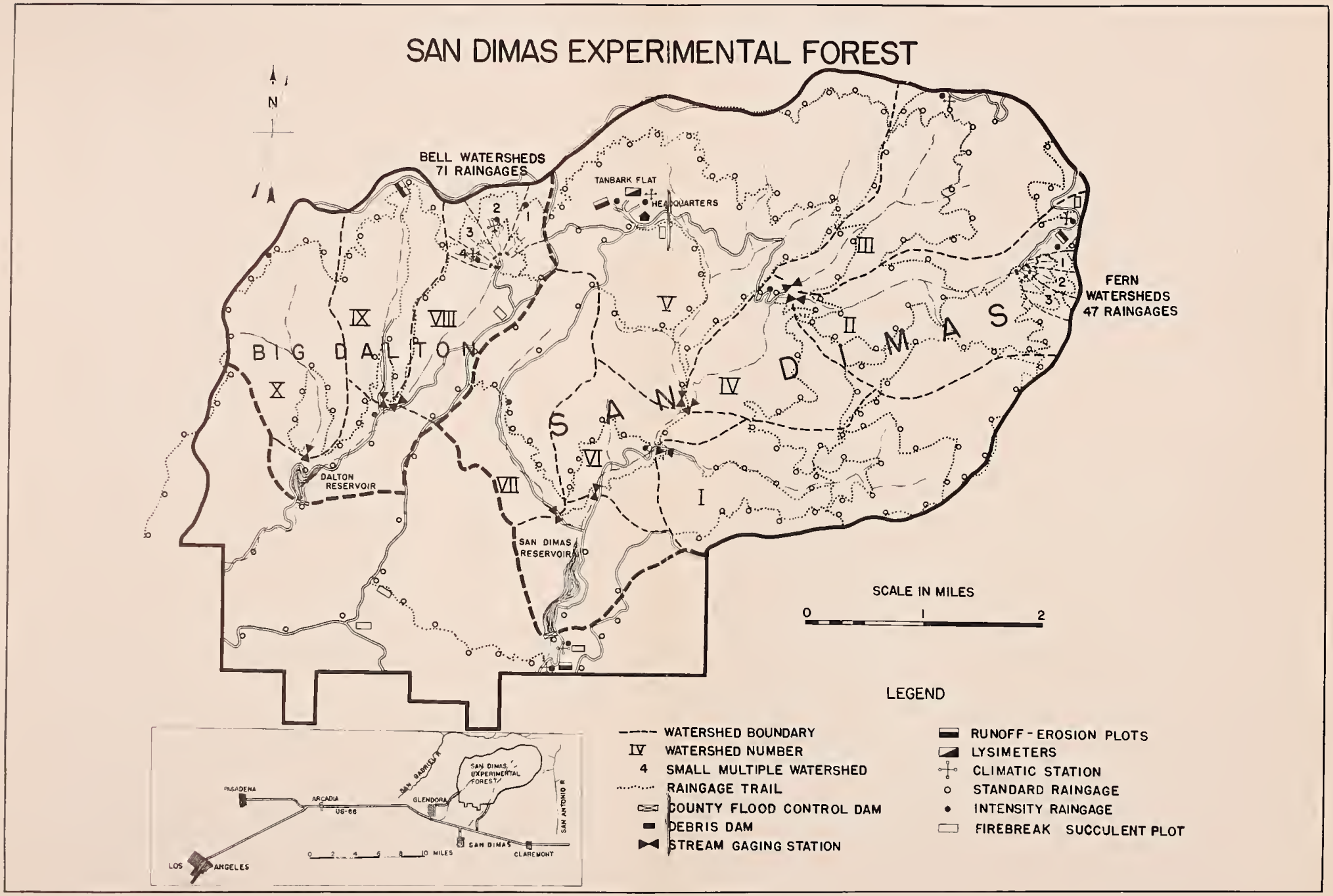
The Experimental Forest owes its present advanced development to the helpful cooperation of many agencies and individuals. Assistance has flowed to the project from so many sources and in such diverse ways that any acknowledgment must inevitably be incomplete. Whether in shaping the broad plan of study, in critically reviewing some detail of experimental technique, or in the actual lending of equipment and facilities, the following list of participants reflects the wide interest of the community in the Experimental Forest:

Angeles Forest Protective Association.
California Institute of Technology.
California State Chamber of Commerce (Conservation Department).
California State Division of Forestry.
Carnegie Institution of Washington.
City of Glendora.
Conservation Association of Los Angeles County.
Los Angeles Chamber of Commerce (Agricultural Dept.).
Los Angeles County Board of Supervisors.
Los Angeles County Flood Control District.
Los Angeles County Forestry Department.
Pasadena City Water Department.
San Dimas Water Company.
San Gabriel Valley Associated Chambers of Commerce.
University of California (especially the faculties of Forestry, Engineering, and Agriculture).

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

In addition, many individual engineers and scientists not in public employ have given liberally of their counsel and constructive criticism.

Finally, emphasis must be laid upon the fact that the heavy construction involved in shaping this forest area into an adequate watershed laboratory has been made possible only through the substantial aid of the Civilian Conservation Corps, the Works Progress Administration and other national emergency relief agencies.

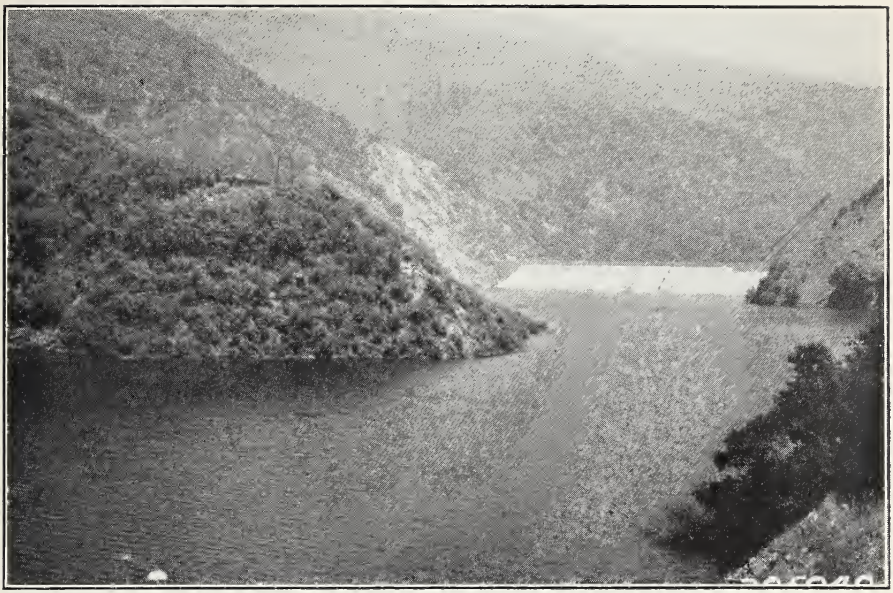

SAN DIMAS EXPERIMENTAL FOREST
N
BELL WATERSHEDS
71 RAINGAGES
TANBARK FLAT
HEADQUARTERS
FERN
WATERSHEDS
47 RAINGAGES
BIG DALTON
SAN DIMAS
DALTON
RESERVOIR
SAN DIMAS
RESERVOIR
SCALE IN MILES
0 1 2
LEGEND
WATERSHED BOUNDARY
WATERSHED NUMBER
SMALL MULTIPLE WATERSHED
RAINGAGE TRAIL
COUNTY FLOOD CONTROL DAM
DEBRIS DAM
STREAM GAGING STATION
RUNOFF - EROSION PLOTS
LYSIMETERS
CLIMATIC STATION
STANDARD RAINGAGE
INTENSITY RAINGAGE
FIREBREAK SUCCULENT PLOT
PASADENA
ARCADIA
US-66
GLENDORA
SAN GABRIEL R
SAN DIMAS EXPERIMENTAL FOREST
SAN ANTONIO R
SAN DIMAS
CLAREMONT
LOS ANGELES
0 2 4 6 8 10 MILES

# SAN DIMAS EXPERIMENTAL FOREST
## DESCRIPTIVE DATA: MAJOR, INTERMEDIATE AND SMALL WATERSHEDS

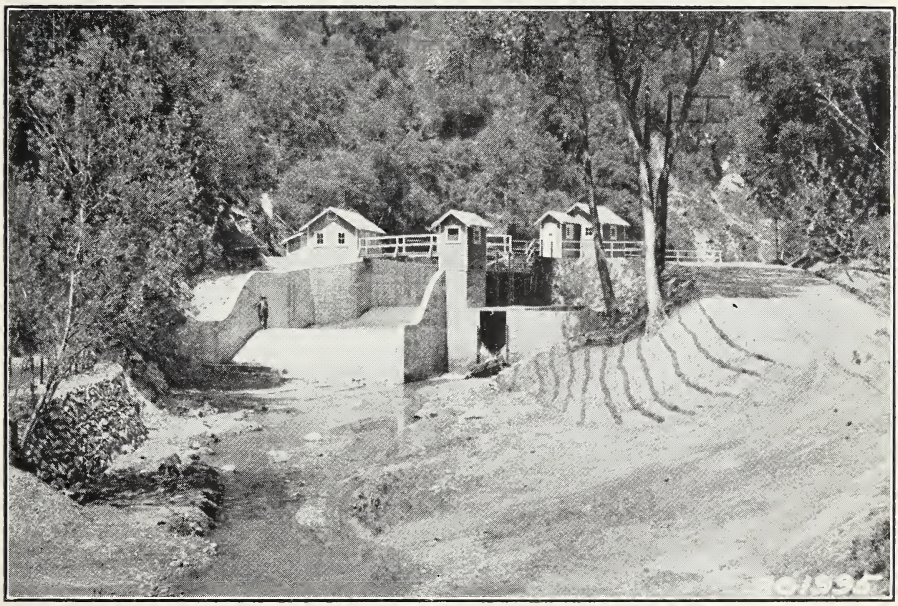
| Watershed | Area Square Miles | Area Acres | Range in Elevation, Feet | Number Rain Gages | | Stream Gaging Stations | | | Reservoir Capacities | Dam Description |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Standard | Intensity | Type | Width Flume | Capacity Sec. Ft. | | |
| **Major** | | | | | | | | | (Acre Ft.) | |
| San Dimas | 15.96 | 10,210 | 1500-5500 | 174 | 10 | | | | 1,820 | Gravity* |
| Big Dalton | 4.25 | 2,720 | 1700-3500 | 102 | 5 | | | | 1,160 | Multiple arch* |
| **Intermediate** | | | | | | | | | | |
| San Dimas Drainage | | | | | | | | | | |
| I Wolfskill | 2.78 | 1,780 | 1700-5200 | 18 | 1 | | 10 | 520 | | |
| II Fern | 2.29 | 1,465 | 2600-5500 | 14 | 2 | | 10 | 500 | | |
| III Upper E. Fork | 2.28 | 1,460 | 2600-5200 | 15 | 1 | | 10 | 580 | | |
| IV East Fork | 5.74 | 3,675 | 1900-5500 | 33 | 3 | | 15 | 1,375 | | |
| V North Fork | 4.75 | 3,040 | 1900-4500 | 35 | 2 | | 15 | 1,160 | | |
| VI Main Fork | 14.30 | 9,150 | 1600-4500 | 94 | 9 | | 30 | 3,520 | | |
| VII West Fork | 1.66 | 1,060 | 1600-3100 | 10 | 1 | | 10 | 450 | | |
| Dalton Drainage | | | | | | | | | | |
| VIII Bell | 1.40 | 895 | 1900-3500 | 9 | 3 | | 10 | 350 | | |
| IX Volfe | 1.29 | 825 | 1900-3500 | 11 | 1 | | 8 | 250 | | |
| X Monroe | 1.56 | 1,000 | 1800-3400 | 16 | 1 | | 10 | 350 | | |
| **Small** | | | | | | | | | (Cu. Ft.) | |
| Bell No. 1 | 0.121 | 77 | 2500-3400 | 18 | 1 | | 3 | 50 | 10,500 | Ambursen |
| No. 2 | 0.158 | 101 | 2500-3500 | 23 | 1 | | 3 | 50 | 10,500 | Ambursen |
| No. 3 | 0.097 | 62 | 2500-3400 | 16 | 0 | | 3 | 50 | 10,000 | Ambursen |
| No. 4 | 0.058 | 37 | 2500-3100 | 14 | 1 | | 3 | 50 | 100,000 | Ambursen |
| Supplementary | | | | | | | | | 325,000 | Ambursen** |
| Fern No. 1 | 0.055 | 35 | 4500-5400 | 13 | 1 | | 3 | 50 | 8,500 | Ambursen |
| No. 2 | 0.063 | 40 | 4500-5400 | 16 | 0 | | 3 | 50 | 10,000 | Ambursen |
| No. 3 | 0.084 | 53 | 4500-5400 | 18 | 0 | | 3 | 50 | 10,000 | Ambursen |
| Supplementary | | | | | | | | | 85,000 | Single arch |

Combination of control flume and 90° V-notch weir, with automatic time-stage recorders and electric depth gauges.

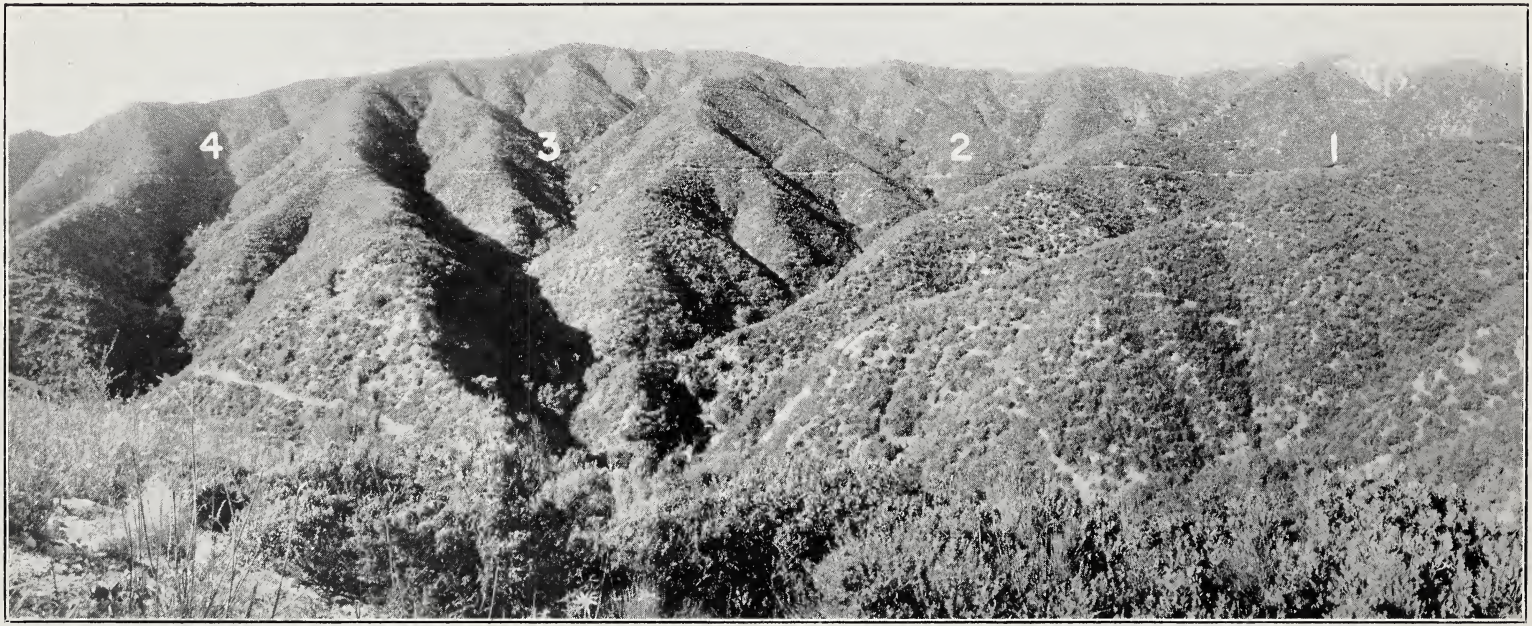
*Los Angeles County Flood Control.
**Ambursen—earth fill.



*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.*

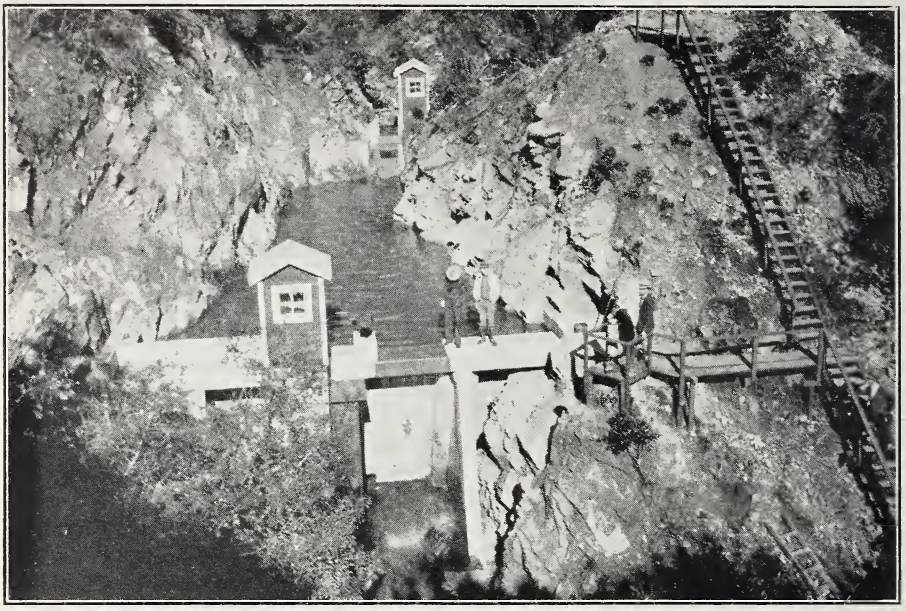



BELL SMALL MULTIPLE WATERSHEDS

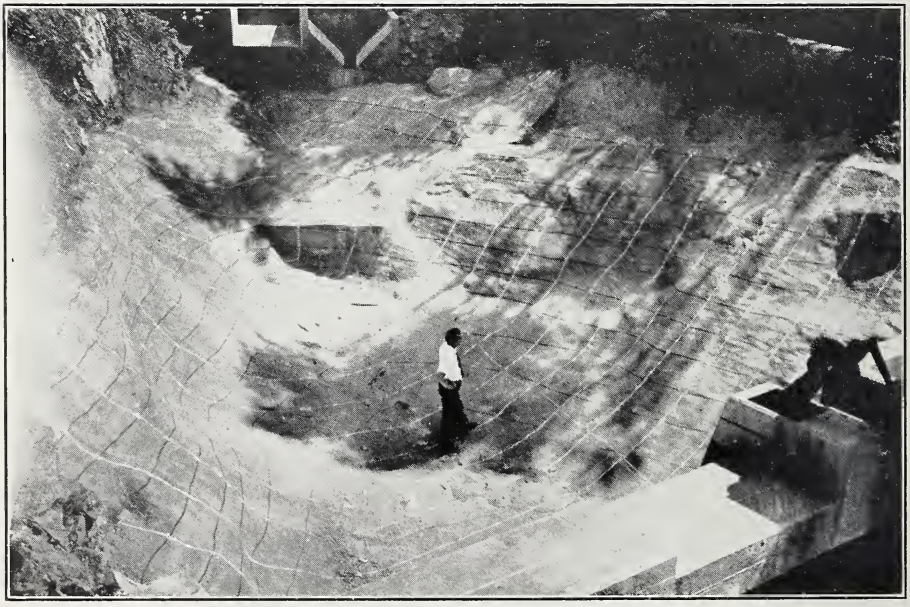
*Area burned in* 1919. *71 rain gages are located on contour trails at* 2500, 2800, 3100 *and* 3400 *feet elevations. Total area* 277 *acres.*


FERN SMALL MULTIPLE WATERSHEDS

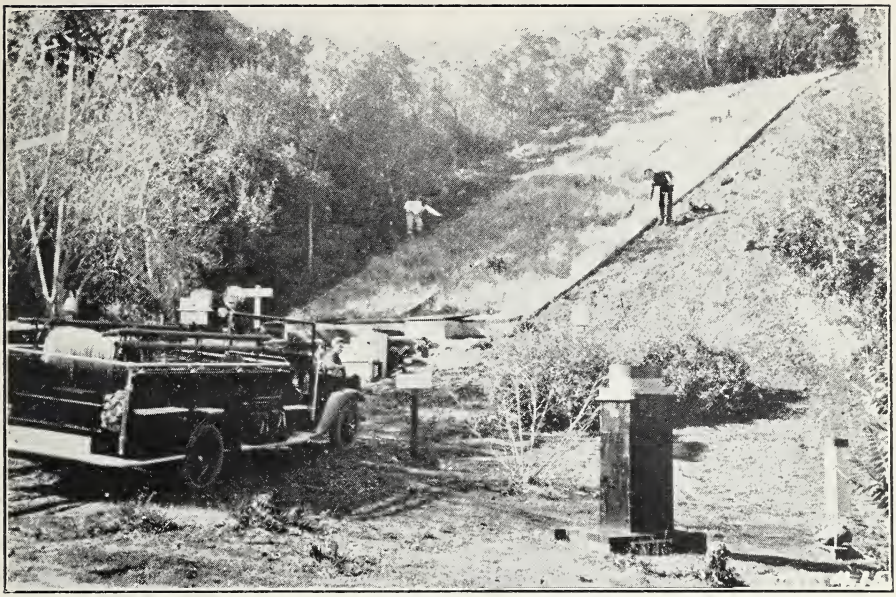
*Vegetation unburned for past 50 years. 47 rain gages are located on contour trails at 4700, 4950 and 5200-foot elevations on total area of 128 acres.*



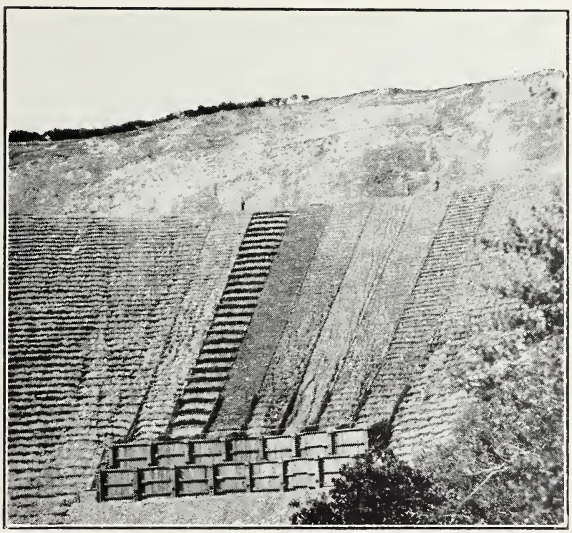
*Installation at mouth of Bell Watershed No. 2. Ambursen type dam used to catch eroded material from 101-acre watershed. Gaging station at head of reservoir provides continuous record of run-off. This installation is typical of six controls for Bell and Fern Watersheds.*



*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 Run-off and Erosion Plots. Annually denuded plots (1/40th acre each) about to be reburned. A pair of plots identical in size are located in original brush cover at left. The rainfall and run-off are measured continuously through tipping bucket devices and recorded electrically on a strip chart. Eroded material is collected in a trough and silt trap at the lower end of each plot.*



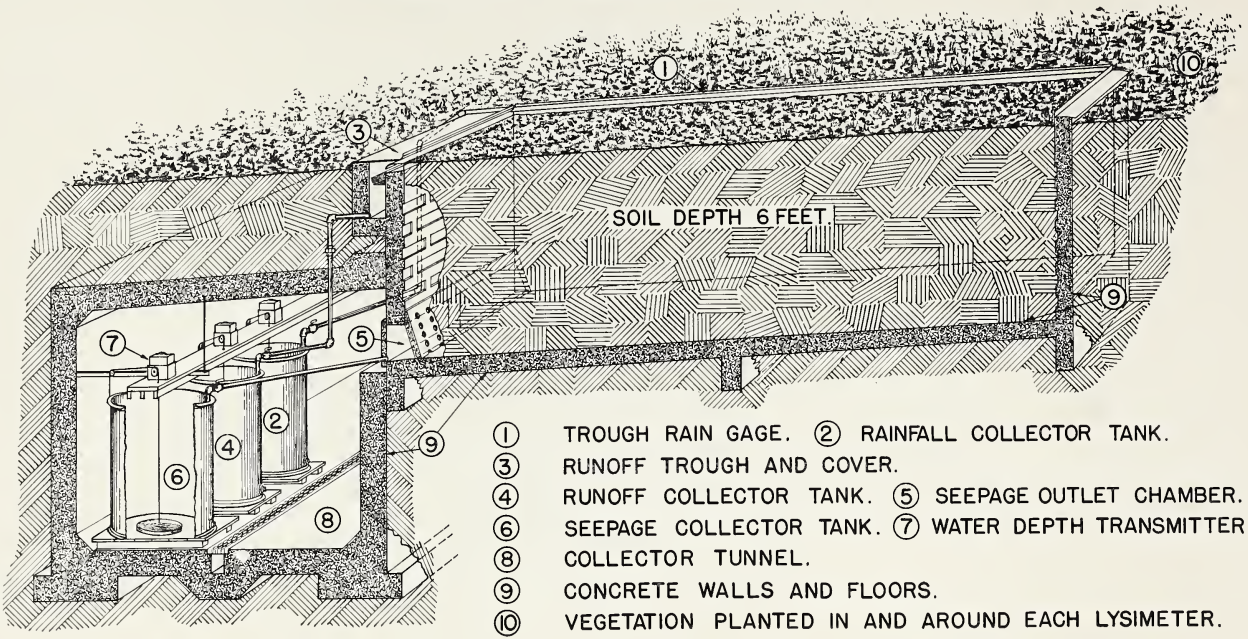
*Volfe Canyon Road Slope Erosion Control Experimental Plots. The effectiveness of various methods of slope fixation is under observation and the erosion from each plot measured in bins at the base of the fill.*

*Climatic Station at 4350 feet altitude equipped for measurement of environmental factors of air and soil.*

*Dormitory for technical assistants at field headquarters of the Experimental Forest, Tanbark Flat.*

# DIAGRAM OF A SINGLE LARGE LYSIMETER

SURFACE AREA 5-MILACRES (10½ 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.

CALIFORNIA FOREST AND RANGE
EXPERIMENT STATION

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*Circular prepared by*

EXPERIMENTAL FOREST STAFF

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