THE FOREST FLOOR OF THE CHAPARRAL IN SAN GABRIEL MOUNTAINS, CALIF.[1]

By Joseph Kittredge, Jr.[2]
Forest ecologist, California Agricultural Experiment Station

INTRODUCTION

The forest floor in the chaparral of southern California as in forests of larger trees has a certain importance in maintaining the productivity of the soil and in such water relations as evaporation, surface run-off, and infiltration. The term "forest floor" is used to designate the total accumulation of organic materials above the mineral soil. The study reported herein was undertaken in an attempt to obtain quantitative measurements of the amount of floor material and its water relations.

REVIEW OF LITERATURE

Earlier determinations of the properties of forest floor from forest stands in the United States and Europe have been summarized by Alway and Zon (*2*).[3] However, none of them originated in the chaparral or its associated prolonged dry summer climate. Maximum dry weights per acre of 119.2 metric tons have been reported for a mixed forest of birch, maple, and spruce in New Hampshire (*8*), and of 87.5 metric tons for spruce, fir, and birch in northern Minnesota (*1*). Low values for well-stocked stands seem to be prevalent in the Southeast where records for mixed hardwoods and shortleaf pine range from 1 to 7 metric tons per acre (*6, 11*) and in Florida, where undisturbed old-growth longleaf pine had only 1.7 metric tons per acre (*3*). In northeastern California, Bodman found 11 metric tons per acre under mature pine and 21 under white fir (*4*). In the mixed conifer forest of the west slope of the Sierra Nevada, 28 metric tons per acre was found by Lowdermilk (*7*). He also recorded 25 tons from the mixed "oak-chaparral" near Berkeley.

Volume weights of 0.26 for pine and from 0.19 to 0.31 for white fir floor were reported by Bodman (*4*).

From the same source, moisture content at cessation of movement ranged from 50 to 85 percent, corresponding to depth of water retained of from 0.15 to 0.3 inch. For the pine-fir floor of the Sierra Nevada, the normal or field moisture capacity averaged 180 percent or 0.26 inch depth of water (*7*). Values for forest-floor material from 100 to as high as 458 percent of the dry weight have been reported (*9*), but it is not certain that the higher figures do not represent moisture content nearer to saturation than to field moisture capacity.

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[3] Italic numbers in parentheses refer to Literature Cited, p. 534.

DESCRIPTION OF THE AREAS STUDIED

The field work was done on two areas on the headwaters of tributaries of Big Dalton and San Dimas Canyons in the San Gabriel Mountains of Los Angeles County. More specifically, one area of 240 acres included three small watersheds at the head of Bell Canyon at elevations of from 2,500 to 3,500 feet; and the other, with an area of 128 acres, three watersheds at the head of Fern Canyon at elevations of from 4,500 to 5,400 feet. These areas, originally called the "triplicate" watersheds, are being studied intensively by the California Forest and Range Experiment Station on the San Dimas Experimental Forest. The work here presented has been carried on with the cordial and helpful cooperation of the Station.[4]

In both areas, the topography is steep and mountainous with narrow V-shaped canyons and only minor development of small tributary drainageways. The slopes vary from 15° to 45° and are clothed with a rather shallow mantle of sandy loam to loam soil, in most places, with considerable admixture of gravel and stones.

Except for an occasional narrow strip of canyon bottom, the Bell Canyon watersheds were almost completely denuded of vegetation by the San Gabriel fire of 1919. Consequently, in 1933, when most of the field work was done, the area was occupied by an even-aged stand of chaparral, 14 years old, composed chiefly of chamiso (*Adenostoma fasciculatum*) and *Ceanothus crassifolius*. These species were important components of the chaparral before the fire and they are typical of large areas at similar elevations where the fire histories have varied widely. Fern Canyon had not been burned for more than 55 years, although fire scars on the occasional larger oaks and bigcone spruces testify to earlier fires. The north and east slopes are clothed with a rather dense stand of canyon live oak (*Quercus chrysolepis*) of sprout origin and the south and west slopes with a mixture of manzanita (chiefly *Arctostaphylos glauca*) and *C. divaricatus*.

The sampling points were distributed mechanically over each area with the intention of obtaining a representation from which, by biometric analyses, inferences might be drawn for the area as a whole. Eighty-four sampling points were studied in Bell Canyon and 101 in Fern. At each one the percentage of crown density or coverage was estimated by species on an area of 1 milacre, and the average height and crown or stem diameter of each species was recorded.

A total of 12 species in Bell Canyon and 7 in Fern Canyon made up the principal woody components, various combinations of which formed the chaparral communities or types. These were segregated and characterized by the one or two predominating species and then combined in broader groups if differences between the types were found not to be significant. The first analysis by types, therefore, included 14 communities in Bell and 11 in Fern Canyon.

These differences in the vegetation within either Bell or Fern Canyon might be expected to be reflected in differences in the floor and its water relations. However, differences between Fern and Bell Canyon, which are separated by about 6 miles and some 2,000 feet in elevation, are doubtless associated with differences in soil and climate as well as with differences in vegetation.

[4] The work was made possible by the allotment of funds from a special State appropriation for research in forestry in cooperation with Federal agencies.

COVERAGE AND DEPTH OF FOREST FLOOR AND CROWN DENSITY

The forest floor, or A_0 horizon, was found to cover from 0.4 to 0.9 of the surface in Bell Canyon and from 0.6 to 1.0 in Fern Canyon, in each case with only three or four exceptions provided by bare spots.

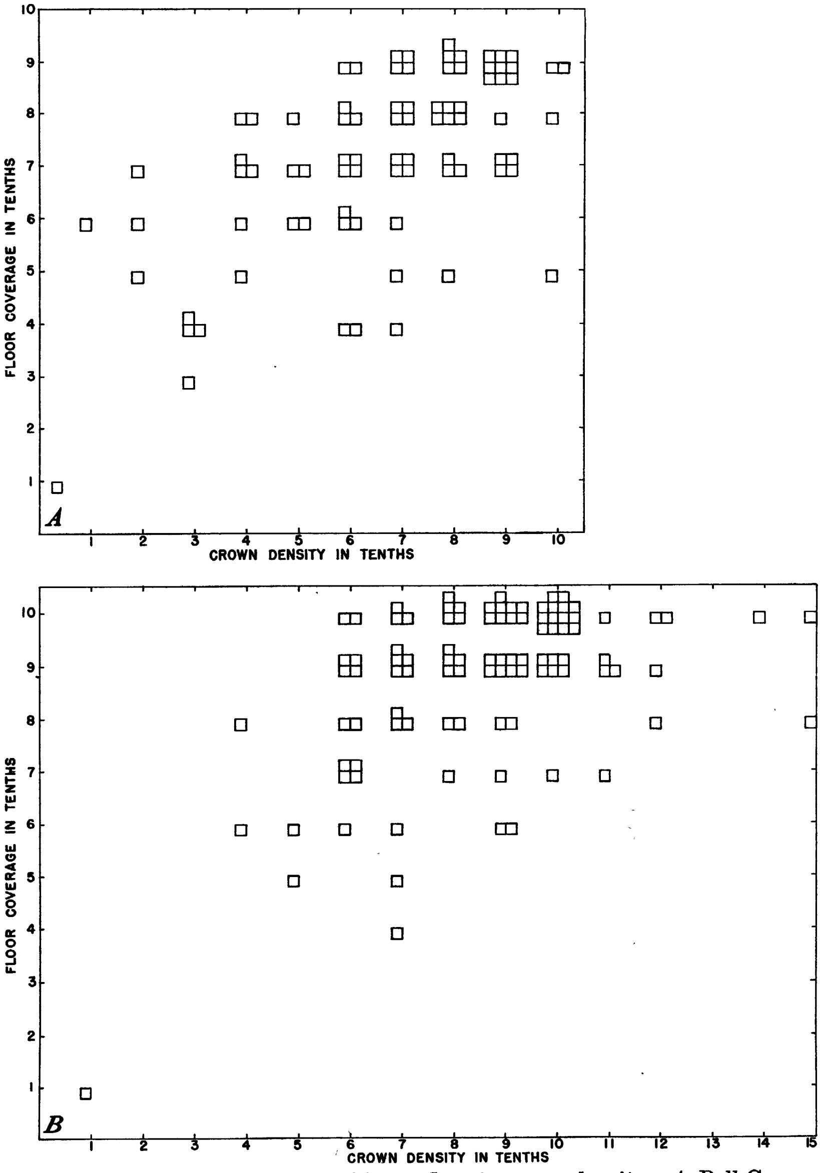

FIGURE 1.—Relation of coverage of forest floor to crown density: *A*, Bell Canyon; *B*, Fern Canyon. Each small square represents one sample.

The distribution of the coverage by the forest floor in relation to the crown density, also expressed on a scale of tenths, is shown in figure 1 for Bell and Fern Canyons. In general the proportion of area covered by the forest floor is somewhat greater than that covered by the crowns. In Bell Canyon, on an average, a floor coverage of 0.8 is associated with a crown density of 0.7, and in Fern Canyon the corresponding figures are 0.9 and 0.8.

In depth the floor varied from 0 to 1 inch, with an average of 0.25 inch in Bell, and up to 2 inches in Fern Canyon, with an average of about 0.6 inch.

AMOUNT OF FOREST FLOOR IN DRY WEIGHT PER ACRE

The amount of the forest floor was determined by collecting samples 1 square foot in area including all the organic accumulation down to the mineral soil, avoiding as far as possible the mineral matter. However, on the steep slopes where there is considerable creep, the separation is difficult to make and samples inevitably include mineral fragments. These were separated by sieving and floating the material in the laboratory; the remaining organic matter was oven-dried for 132 hours at 70° to 80° C.[5] The resulting weights converted to an area of 1 acre will be termed "dry weight per acre."

These dry weights of single samples varied from 0.0 to 20.4 metric tons per acre for Bell Canyon, and up to 37.6 for Fern Canyon. The averages by chaparral types ranging from 2.9 to 21.2 metric tons per acre are shown in tables 1 and 2. The figures for number of samples show the distribution of sampling points by types and, since the sampling points were mechanically spaced, they give an indication of the relative abundance of the different types. Thus the types that occupy only small areas are represented by only a few samples and the averages for these less extensive types are correspondingly less reliable.

TABLE 1.—*Dry weight of forest floor in Bell Canyon*

Group and chaparral type [1]	Means of dry weight per acre	Standard error	Coefficient of variation	Samples	Significance of differences between means [2]				
					Sm-Eff	Eff	Qd-Ccr	Af-Ccr	Af-Sm
	Metric tons	*Metric tons*	*Percent*	*Number*					
High group:									
Ro [1]	12.33	4.02	45.9	2	s	s	n	h s	n
Gv	9.50			1					
Sm-Ccr	7.40	1.72	52.0	5	n	n	n	s	n
Pa	7.22	1.29	30.8	3	s	n	n	n	n
Ccr-Sm	6.72	1.71	84.3	11	n	n	n	n	n
Cb	6.23	3.92	88.8	2					
Co-Qwf	5.74	2.92	71.8	2					
Medium group:									
Ccr-Af	5.17	1.02	89.5	21					
Af-Sm	4.82	1.47	74.3	6					
Af-Ccr	4.21	.58	55.4	16					
Ag	4.13			1					
Qd-Ccr	3.75	1.14	60.2	4					
Low group:					Medium and low		Low	Medium	
Eff	3.27	.80	54.1	5					
Sm-Eff	2.92	.85	65.0	5					
Group means:									
High	7.33	1.00	69.2	26	h s		s	s	
Medium	4.67	.53	78.5	48	n		n	n	
Low	3.10	.59	59.6	10					
Medium and low	4.40	1.01	79.1	58					
All types	5.31	.46	79.3	84					

[1] Abbreviations as here used are as follows: Af, *Adenostoma fasciculatum*, chamiso; Ag, *Arctostaphylos glauca*, manzanita; Cb, *Cercocarpus betuloides*, mountain-mahogany; Ccr, *Ceanothus crassifolius*,; Co, *C. oliganthus*, hairy ceanothus; Eff, *Eriogonum fasciculatum* var. *foliolosum*, wild buckwheat; Gv, *Garrya veatchii*, silktassel; Pa, *Photinia arbutifolia*, christmasberry; Qd, *Quercus dumosa*, scrub oak; Qwf, *Q. wislizenii* var. *frutescens*, interior live oak; Ro, *Rhus ovata*, sugar sumac; Sm, *Salvia mellifera*, black sage.

[2] s=significant; hs=highly significant; n=not significant.

[5] The dry weights thus obtained were found by test to be from 0.3 to 0.9 percent higher than those in an oven at 105° C. The lower temperature was used to avoid losses by combustion.

TABLE 2.—*Dry weight of forest floor in Fern Canyon*

Group and chaparral type [1]	Means of dry weight per acre	Standard error	Coefficient of variation	Samples	Significance of differences between means [2]				
					Pm	Qc	Qwf	Qc–Qwf	Qc–Ag
	Metric tons	*Metric tons*	*Percent*	*Number*					
High group:									
Ag [1]	21.18	3.70	49.4	8	n	h s	n	n	
Ag–Af	20.56	3.89	42.3	5	n	s	n	n	
Ag–Cd	20.16	1.84	32.8	13	s	h s	s	s	n
Cd–Ag	19.74	2.93	33.2	5	s	n	n	n	
Medium group:									
Qwf–Ag	17.57	4.02	51.1	5	------	n			
Qc–Ag	15.42	3.53	56.1	6					
Low group:									
Qc–Qwf	12.84	2.21	45.6	7					
Qwf	12.29	1.72	36.9	7					
Qc	12.24	3.76	67.6	40	Low	Medium			
Pm	10.11	1.50	25.3	4					
Af	4.69	----------	----------	1					
Group means:									
High	20.42	1.46	39.8	31	h s	n			
High and medium	19.37	1.31	43.9	42	h s				
Medium	16.40	2.67	54.1	11	n				
Low	12.04	.90	58.2	59					
All types	15.09	.84	56.4	101					

[1] Abbreviations used: Ag, *Arctostaphylos glauca*, manzanita; Af, *Adenostoma fasciculatum*, chamiso; Qc, *Quercus chrysolepis*, canyon live oak; Cd, *Ceanothus divaricatus*; Qwf, *Quercus wislizenii* var. *frutescens*; interior live oak; Pm, *Pseudotsuga macrocarpa*, bigcone-spruce.
[2] See footnote 2, table 1.

The point that stands out in these figures is that the differences in the average weight of floor in different types are small. These differences were tested for significance by the *F* test in the analysis of variance as outlined by Snedecor (*12*), and the expectation was verified that many of the types are not significantly different one from another in average dry weight of floor per acre. The significance of the difference is indicated in the right-hand columns of the tables, where the types or groups from the low end of the series are repeated as headings of the columns to form a cross classification with the types or groups of the high end of the series in the left-hand column. On that basis the types were combined into three groups for each of the two canyons in such a way that differences between groups would be significant and, at the same time, the groups would include types that seemed to have some logical interrelation.

The 12 species that are commonly represented in Bell Canyon and give character to the chaparral communities occur in various mixtures in which the relations to site or to natural succession are not well defined. Almost all the species were included by Cooper (*5*) as components of the chaparral climax. If they have successional relations, the 14 years since the last fire has not been sufficient for their expression. It seems likely that the *Rhus* and *Garrya* and *Photinia*, which have heavy accumulations of forest floor, may represent more persistent species in succession than the *Eriogonum* and chamiso (Af), which have light forest floors. Actually, by the test of significance, the *Rhus* with an average of 12.33 metric tons per acre is significantly different from the *Eriogonum* types with less than 3.3 metric tons, and from the chamiso—*Ceanothus crassifolius* type with 4.21 metric tons. This latter type is also significantly different from the type in which the black sage (Sm) is dominant in association with the *Ceanothus* and in which the forest floor averages 7.4 metric

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tons. The only other case of a significant difference between means is that of Christmasberry (Pa) with 7.22 metric tons, as compared with the black sage and *Eriogonum* with 2.92 metric tons. Obviously there is little justification for distinguishing the 14 types on the basis of the amount of forest floor.

When they are combined in three groups, some of the homogeneity of the individual types is lost, with a compensating gain in differentiation. The low group, with an average dry weight of forest floor of 3.1 metric tons, is characterized by the *Eriogonum;* the intermediate group, with 4.67 metric tons, contains the types with chamiso; and the high group, with 7.33 metric tons, a variety of types including those which have been suggested as more persistent. Between the means of these three groups, the high is significantly different from both the medium and the low, but the intermediate group is not significantly different from the low. Going a step further, therefore, and combining the intermediate and low groups, with further loss of homogeneity, there remains a high group with a mean dry weight of 7.33, which is significantly different with a probability of 100 to 1 from the combined low group with a mean of 4.4 metric tons per acre.

The variation within the types and in the groups is high throughout, as indicated by the magnitudes of the coefficients of variation, which range from 30.8 to 89.5 percent. The means of the two groups, high and medium and low, have standard errors of 1 metric ton per acre, which may be interpreted by saying that another sample of the same size from watersheds with similar vegetation would give means for the high group ranging between 6.3 and 8.3 and for the low group between 3.4 and 5.4 metric tons, with a probability of 68 in 100.

In Fern Canyon at elevations between 4,500 and 5,400 feet, the means for the forest floor in the different types range from 4.7 metric tons for chamiso (Af) to 21.18 for manzanita (Ag). The four types in which manzanita occurs pure or in mixture with chamiso or *Ceanothus divaricatus* are higher, and usually significantly higher, in dry weight of floor than the types characterized by oak or spruce or chamiso. If three groups of types are distinguished, only the high group of manzanita types is distinct from the low group with the oak (Qc, Qwf), bigcone-spruce (Pm), and chamiso. If the two types in which manzanita and oak are associated and the other types in which manzanita is present are combined, the resulting group with a mean weight of forest floor of 19.37 metric tons differs with high significance from the low group with 12.04 metric tons.

Again the variation within types and groups is high, ranging from about 25 to 68 percent and the standard errors of the group means, when only two groups are distinguished, are 1.3 metric tons for the high and medium and 0.9 for the low group. In this case, however, these two groups, the high one characterized by manzanita and the low one by oak or spruce, are quite definitely associated with a difference in site. The former is found on the south and west aspects, while the latter occurs on the north and east aspects and in the canyon bottoms.

When the 14-year-old chaparral of Bell Canyon below 4,000 feet is compared with the more than 50-year-old vegetation of Fern Canyon above 4,000 feet, the difference between 5.3 and 15.0 metric tons per acre dry weight of forest floor is highly significant.

An attempt was made to investigate the relation of the amount of forest floor to the foliage volume. As an expression of foliage volume, the product of the average height of the vegetation in feet and the crown density in tenths was used. This gave a scale ranging from less than 1 to 35. In Bell Canyon, where the foliage or crown length closely approached the height of the chaparral, there was a poorly defined tendency for the dry weight of forest floor to increase in a somewhat linear trend as the foliage volume increased. For separate groups of the chaparral types, however, the trend disappeared. In Fern Canyon, nothing that could be called a trend was found, perhaps because, with the oaks particularly, the total height was not a good index of crown length. In any case, no evidence was found of a usable relation between dry weight of forest floor and foliage volume.

VOLUME WEIGHT OF FOREST FLOOR

The volume weight of the forest floor, determined as the ratio of the oven-dry weight to the weight of an equal volume of water, provides a measure of the density of the floor material and might be expected to reflect differences in the moisture relations or in the composition of the chaparral as it influences the underlying mineral soil. The term "volume weight" is used as a synonym for "apparent specific gravity." The volume weights were obtained from the dry weights and the measurement of average depth of the square-foot samples from which volumes were computed. The average volume weights of the different chaparral types in Bell and Fern Canyons, together with the biometric analysis, are shown in tables 3 and 4.

TABLE 3.—*Volume weights of forest floor in Bell Canyon* [1]

Group and chaparral type	Volume weight	Standard error	Coefficient of variation	Samples	Significance of differences between means				
					Cb	Qd–Ccr	Co–Qwf	Sm–Eff	Ccr–Sm
High group:			*Percent*	*Number*					
Pa	0.27	0.02	13.6	3	s	n	s	n	n
Af-Sm	.26	.05	48.4	6	n	n	n	n	
Ro	.26	.004	2.8	2	s	n	s	n	
Sm-Ccr	.25	.03	25.6	5	s	n	n		
Af-Ccr	.24	.03	43.7	15	n	n			
Medium group:									
Eff	.23	.02	13.9	4	s	n	n		
Ccr-Af	.22	.01	50.9	21					
Ccr-Sm	.20	.03	58.3	11					
Sm-Eff	.18	.05	61.6	5					
Low group:									
Co-Qwf	.16	.02	22.6	2					
Qd-Ccr	.15	.05	69.5	4					
Gv	.09	----------	----------	1					
Cb	.08	.02	38.1	2	Low		Medium		
Ag	.08	----------	----------	1					
Group means:									
High	.25	.02	38.9	31	h s		n		
Medium	.21	.02	51.4	41	s				
Low	.13	.02	61.1	10					
All types	.21	.01	49.5	82					

[1] For meaning of abbreviations see footnotes, table 1.

In Bell Canyon the range is from 0.08 to 0.27. The differences in the means between different types are small and consequently only a few of the higher ones are significantly different from the lower ones. Such significant differences as are found are between the less extensive types, such as Christmasberry (*Pa*) or *Rhus*, with volume weights of

TABLE 4.—*Volume weights of forest floor in Fern Canyon* [1]

Group and chaparral type	Volume weight	Standard error	Coefficient of variation	Samples	Significance of differences between means					
					Qc-Ag	Qwf-Ag	Qc	Qwf	Qc-Qwf	Ag
High group:			*Percent*	*Number*						
Af	0.36	----------	----------	1	------	------	------	------	------	------
Ag-Cd	.29	0.02	20.4	13	h s	h s	h s	h s	s	n
Ag-Af	.28	.01	7.2	5	h s	h s	s	n		
Cd-Ag	.27	.03	27.4	5	s	n	n			
Pm	.25	.02	17.9	4	s	n	n			
Ag	.25	.02	25.2	8	s	n				
Low group:										
Qc-Qwf	.21	.03	42.0	7						
Qwf	.20	.03	35.5	7						
Qc	.19	.01	42.7	39						
Qwf-Ag	.18	.02	27.7	5						
Qc-Ag	.17	.02	28.4	6						
Group means:					Low					
High	.27	.01	22.6	36	h s					
Low	.19	.01	40.4	64						
All types	.22	.01	36.9	100						

[1] For meaning of abbreviations see footnotes, tables 1 and 2.

0.27 and 0.26, and *Cercocarpus betuloides* (Cb) or *Ceanothus oliganthus* and oak (Co–Qwf), with volume weights of 0.08 and 0.16.

The sequence of the types in descending order of the mean volume weights is not the same as was found in the analyses of dry weight or of percentage field moisture capacity or of depth of water retained. Correspondingly, the groups that can be formed on the basis of volume weight are not the same as those distinguished in the other analyses. However, if the groups on any other basis were used, there would be neither homogeneity within nor significant differences between them. It seems better, therefore, to differentiate the groups independently for volume weight; and for that purpose three groups designated "high," "medium," and "low" are distinguished. The high group, with mean volume weight of 0.25, coefficient of variation of 38.9 percent, and standard error of 0.02, contains the types in which chamiso (Af) predominates, together with Christmasberry, *Rhus*, and the black sage (Sm) with admixture of *Ceanothus crassifolius*. The intermediate group includes the two types in which *C. crassifolius* is dominant and the two in which *Eriogonum* is found. This group has a mean volume weight of 0.21, coefficient of variation of 51 percent, and standard error of 0.02. The low group includes the two types in which oak (Qd, Qwf) is an element, together with the *Garrya*, manzanita (Ag), and *Cercocarpus betuloides*.

As between these groups, the low is different from the high group with high significance, and is also significantly different from the medium group. The high and medium groups are not significantly different one from another. The coefficients of variation expressing the dispersion of the individual samples making up a type or group, and the standard errors representing the value of the means for purposes of generalization or prediction are not very different for the groups from their values for the types. In other words, the subdivision of the vegetation into a larger number of types does not increase either the homogeneity of the units or the value of the means for application to larger areas of similar vegetation.

In Fern Canyon, the volume weights for the chaparral types vary from 0.17 to 0.36. In general the variation within types is less than was the case in Bell Canyon, as might be anticipated from the fact that the types in Fern Canyon have had an opportunity to develop characteristic properties undisturbed over a much longer period of time. Although the range of the mean volume weights and the differences between individual types are not greater than in Bell Canyon, the types with high volume weight are in many cases significantly different from those with low. Thus the types with manzanita (Ag) are significantly different, and in several cases with probabilities of more than 99 in 100, from the types in which either oak (Qc, Qwf) predominates.

These types on the bases of biometric analysis, composition, and site fall rather definitely into two groups. The high group contains the mixtures of manzanita, chamiso (Af), and *Ceanothus divaricatus*, together with the bigcone-spruce (Pm). This group has a mean volume weight of 0.27 with a coefficient of variation of 22.6 percent and standard error of 0.01. The low group contains all of the oak types and their mixtures and has a mean volume weight of 0.19 with a coefficient of variation of 40.4 percent and a standard error of 0.01. The satisfactory basis for the separation of these two groups is confirmed by the finding that the difference between their means is highly significant.

The mean volume weight of 0.21 for all of the samples from Bell Canyon is not significantly different from the closely corresponding value of 0.22 for Fern Canyon.

FIELD MOISTURE CAPACITY

The field moisture capacity of the floor samples was determined in the laboratory by a modification of the method proposed by Shaw (*10*). After the mineral matter had been separated and removed, the sample was placed in a metal cylinder and immersed in water for 48 hours. The cylinders were then removed and allowed to drain for a few minutes until the freely flowing water had drained off. They were then placed on boxes of dry loam soil, the floor material being separated from the mineral soil of the boxes by a layer of cheesecloth. The tops of the cylinders were sealed with waxed cloths to prevent loss of moisture by evaporation. The samples were left to drain in this way for 48 hours, when the floor was removed and all or a portion of it dried as a basis for expressing the field moisture capacity as a percentage of the oven-dry weight.

This method was found to give results not reproducible within about 10 percent. Tests were made of the effect of resoaking and running samples a second time, of using a sandy loam in comparison with the loam soil, of setting only one instead of three cylinders in a single soil box, and of rearranging the forest-floor material in the cylinders. None of these tests showed any consistent effect on the amount of moisture retained, or on the percentage of field moisture capacity. It seems reasonable to conclude, therefore, that, although individual determinations are not closely reproducible, the means of several determinations within a type or group are reliable as indicating the retention of capillary moisture by the floor.

As in the case of dry weights, the field moisture capacity was first investigated for the individual chaparral types. The figures are shown in tables 5 and 6.

TABLE 5.—*Field moisture capacity of forest floor in Bell Canyon* [1]

Group and chaparral type	Mean field moisture capacity	Standard error	Coefficient of variation	Samples	Significance of differences between means: Ccr-Af	Af-Ccr	Ccr-Sm	Af-Sm
	Percent	*Percent*	*Percent*	*Number*				
High group:								
Co-Qwf	191	18	14	2	h s	h s	n	n
Eff	190	18	19	4	h s	h s	n	n
Ro	178	5	4	2	s	s	n	n
Medium group:								
Qd-Ccr	165	21	25	4	n	n	n	n
Pa	164	11	11	3				
Cb	162	26	22	2				
Sm-Ccr	161	7	10	5				
Sm-Eff	159	8	11	5				
Af-Sm	147	10	16	6				
Ccr-Sm	145	11	26	11				
Low group:								
Gv	140			1				
Af-Ccr	139	5	13	15				
Ccr-Af	139	4	14	21				
Ag	125			1				
					Low	Medium		
Group means:								
High	187	10	16	8	h s	s		
Medium	154	5	20	36	s			
Low	139	3	13	38				
All types	150	3	20	82				

[1] For meaning of abbreviations see footnotes, table 1.

TABLE 6.—*Field moisture capacity of forest floor in Fern Canyon* [1]

Group and chaparral type	Mean field moisture capacity	Standard error	Coefficient of variation	Samples	Significance of differences between means: Ag-Cd	Ag-Af	Cd-Ag	Ag	Qwf-Ag	Qc-Ag
	Percent	*Percent*	*Percent*	*Number*						
High group:										
Qc	173	4	15	40	h s	h s	s	s	s	n
Qc-Qwf	171	10	15	7	h s	s	s	n	n	
Pm	167	16	19	4	s	n	n	n		
Medium group:										
Qwf	158	12	19	7	s	n	n	n		
Qc-Ag	154	15	25	6	n	n	n	n		
Qwf-Ag	148	8	12	5						
Low group:										
Ag	144	9	18	8						
Cd-Ag	138	6	10	5						
Af	138			1						
Ag-Af	135	8	14	5						
Ag-Cd	130	5	15	13						
					Low	Medium				
Group means:										
High	172	4	16	51	h s	s				
Medium	154	7	20	18	s					
Low	136	4	15	32						
All types	157	3	19	101						

[1] For meaning of abbreviations see footnotes, tables 1 and 2.

In general, the two predominating types in Bell Canyon, composed of mixtures of chamiso (Af) and *Ceanothus crassifolius*, and the four types with strong admixtures of black sage (Sm), tend to have a low field moisture capacity, that is, about 140 percent of the dry weight; whereas the oak (Qd, Qwf), *Eriogonum*, *Rhus*, and Christmasberry (Pa) have high average percentages ranging from 164 to 191. The total range for the types in Bell Canyon is only from 125 to 191 percent. The standard errors of the means range from 4 to 26 percent. The coefficients of variation for the individual types, ranging from 4 to 26 percent, are fairly low. This is in contrast to the high variability which was found for the dry weights and other properties. Considering the limited range and the small differences between individual types, it is not surprising that most of them are not significantly different, one from another. Only the types with chamiso and *C. crassifolius* at the low end are significantly different from the *C. oliganthus*-oak, *Eriogonum*, and *Rhus* types at the high end.

When the three last-named types are combined in a group with an average field moisture capacity of 187 percent, this group is significantly different from the low group containing the chamiso-*Ceanothus crassifolius*, and single samples of the manzanita (Ag) and *Garrya* types, and also from the intermediate group containing the seven other types. These groups have coefficients of variation from 13 to 20 percent and standard errors from 3 to 10 percent.

Between the field moisture capacities and the amounts of forest floor, there is no definite relation either in the individual types or in the composition of the groups.

In Fern Canyon, the range of the means of field moisture capacity for individual types is from 130 to 173 percent. The five types at the lower end are those which have no oak and in which manzanita (Ag) is an important element, usually in mixture with chamiso (Af) or *Ceanothus divaricatus*. Canyon live oak (Qc) heads the list with 173 percent, and the mixture of canyon and interior live oaks (Qwf) and bigcone-spruce (Pm) are the next two in order. Notwithstanding the small range and small differences between mean field moisture capacities of the different types, the canyon live oak and spruce types are significantly different from most of the manzanita types. The coefficients of variation for individual types are again low, ranging from 10 to 25 percent and the standard errors of the means from 4 to 16 percent.

The types may be combined in three groups, a high group with canyon live oak or bigcone-spruce and without manzanita, with an average field moisture capacity of 172 percent; a low group, including four manzanita types without oak, having a field moisture capacity of 136 percent; and an intermediate group in which interior live oak or the mixture of oak and manzanita are represented, with a mean field moisture capacity of 154 percent. These three groups are significantly different, one from another. The coefficients of variation are from 15 to 20 percent; and the standard errors, from 4 to 7 percent.

In this instance of Fern Canyon, it is evident that the field moisture capacities of the different types tend to be inversely proportional to the dry weights of the forest floor; that is, the manzanita types which have high weight of floor have low field moisture capacities; and the oak and bigcone-spruce types which have low weights of forest floor tend to have high field moisture capacities.

When the forest floors of Fern and Bell Canyons are compared, the field moisture capacities are not significantly different.

DEPTH OF WATER RETAINED

If the weights of the forest-floor samples are multiplied by the percentages of water retained at field moisture capacity, and the product divided by a suitable constant, figures are obtained for the inches depth of water retained by the forest floor at field moisture capacity on the basis of oven-dry weight. The results of these computations, together with the biometric analysis, are shown for the different chaparral types and groups for Bell Canyon in table 7 and for Fern Canyon in table 8.

TABLE 7.—*Depth of water retained by forest floor at field moisture capacity in Bell Canyon* [1]

Group and chaparral type	Water at field moisture capacity	Standard error	Coefficient of variation	Samples	Significance of differences between means				
					Sm-Eff	Qd-Ccr	Af-Ccr	Eff	Ccr-Af
High group:	*Inches*	*Inches*	*Percent*	*Number*					
Ro	0.21	0.06	43	2	n	n	s	n	n
Gv	.13			1					
Sm-Ccr	.12	.03	61	5	n	n	s	n	n
Cb	.12	.08	93	2	n	n	n	n	
Co-Qwf	.12	.07	78	2	n	n	n	n	
Pa	.11	.02	28	3	s	n	s	n	
Ccr-Sm	.10	.02	79	11			n		
Low group:									
Af-Sm	.07	.03	82	6					
Ccr-Af	.07	.02	93	21					
Eff	.06	.02	60	5					
Af-Ccr	.06	.01	60	15					
Qd-Ccr	.06	.02	57	4					
Ag	.05			1	Low				
Sm-Eff	.04	.01	63	5					
Group means:									
High	.12	.02	75	26	hs.				
Low	.06	.01	83	57					
All types	.08	.01	87	83					

[1] For meaning of abbreviations see footnotes to table 1.

TABLE 8.—*Depth of water retained by forest floor at field moisture capacity in Fern Canyon* [1]

Group and chaparral type	Water at field moisture capacity	Standard error	Coefficient of variation	Samples	Significance of differences between means		
					Pm	Qwf	Qc
High group:	*Inches*	*Inches*	*Percent*	*Number*			
Ag	0.29	0.04	43	8	n	n	n
Cd-Ag	.26	.04	33	5	n	n	
Ag-Af	.26	.05	40	5	n	n	
Qwf-Ag	.26	.07	62	5	n		
Qc-Ag	.26	.08	74	6			
Ag-Cd	.25	.03	42	13			
Low group:							
Qc-Qwf	.21	.04	50	7			
Qc	.20	.02	62	40			
Qwf	.18	.03	38	7			
Pm	.16	.02	24	4	Low		
Af	.06			1			
Group means:							
High	.26	.02	47	42	s		
Low	.19	.02	59	59			
All types	.22	.01	55	101			

[1] For meaning of abbreviations see footnotes to tables 1 and 2.

Because the types with the larger amounts of forest floor tend to have lower field moisture capacities and vice versa, the figures for depth of water retained, which integrate the two, would be expected to be less definitely differentiated. This proved to be the case. In

Bell Canyon the range of the means of the different types is from 0.04 to 0.21 inch. Only the mixed type of chamiso (Af) and *Ceanothus crassifolius*, and in one case the black sage (Sm)–Eriogonum mixture less common types are significantly different from certain of the black sage (Sm) mixtures.

When the types in Bell Canyon are grouped, a high group of seven types is found to be identical with the high group that was distinguished on the basis of dry weights of forest floor. The other seven types, including those with chamiso (Af) and *Eriogonum*, comprise a rather homogeneous group, characterized by low values for depth of water retained. The mean for the high group is 0.12 inch and for the low group 0.06 inch, and these two groups differ one from another with high significance.

The analysis shows somewhat similar results in Fern Canyon, except that the depth of water retained by the different types is greater with only two exceptions. The range, excluding a single sample of chamiso, is from 0.16 to 0.29 inch. The individual types are not significantly different one from another.

When the types in Fern Canyon are grouped, those with low values for mean depth of water retained form the same group of five types without manzanita which comprised the low group for dry weight of forest floor. The other six types containing manzanita (Ag) form a group with high values. The mean for this high group is 0.26 inch and for the low group 0.19, and the two groups are significantly different one from another.

There is almost no overlapping in the mean values of individual types between Bell and Fern Canyons, and the means for the respective watersheds are significantly different.

These figures for depth of water retained at field moisture capacity on the basis of oven-dry weight have special interest because they represent the depth of precipitation which would be retained by the forest floor, subject to evaporation into the air, and which would therefore not be available either for the growth of vegetation or for replenishing soil moisture or ground water. However, to use them in this way, a correction must be made because the forest floor under natural conditions is never reduced to an oven-dry condition. During dry weather the floor usually contains about 15 percent moisture content on the basis of oven-dry weight. Hence the figures for field moisture capacity in percentage would be reduced by 15 percent, or by the percentage of actual moisture content at the beginning of any rain, and the figures for depth of water retained could be reduced correspondingly. In light rains the forest floor may be a factor of some importance in intercepting moisture which would otherwise reach the soil. In heavy rains, on the other hand, it will affect only a negligible part of the total rainfall.

SUMMARY

The forest floor under the chaparral covers a large part of the surface within 15 years after a heavy burn.

The amount of forest floor varies widely within any given type of chaparral, although differences in means between types are small and only significant between the extremes. The differences become sig-

nificant if the chaparral is segregated into only two or three broad groups such as those characterized by chamiso (Af), manzanita (Ag), or oak (Qc, Qwf). The 15 metric tons average for Fern Canyon is almost three times that for Bell Canyon.

The mean volume weights for individual types vary from less than 0.1 to 0.36. In Fern Canyon there is a well-defined differentiation between the types or group with high means in which manzanita, chamiso, or bigcone spruce (Pm) predominate, and those with low means in which the oaks predominate.

Field moisture capacities vary less within types than the other measures. Three groups within each canyon show a significant difference in the means, although the difference between 157 percent in one canyon and 150 percent in the other is not significant. In general the manzanita, *Ceanothus*, and chamiso are associated with low field moisture capacities of the floor, and oak and big cone spruce with high.

The depth of water retained by the forest floor represents an integration of amount, volume weight, and field moisture capacity of the materials, and gives an indication of the role of the forest floor in intercepting rainfall. Like its component elements, it varies within types to such an extent that the small differences between the means of types are rarely significant. The groups of types, however, are distinct, a low group in Bell Canyon retaining 0.06 inch, a high group, 0.12 inch; and in Fern Canyon, a low group, 0.19, and a high group, 0.26 inch. These amounts, less the actual moisture content at the beginning of rain, would be held subject to evaporation from the forest floor and would not contribute to soil moisture or to surface run-off.

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