Some Characteristics of Forest Floors From a Variety of Forest Types in California

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THE ADVANTAGES or disadvantages of the layer of organic material on the surface of the soil are sufficiently important in silviculture and fire suppression as well as in watershed management, that quantitative information about the forest floor may be useful in several ways. The following data on the influences of different kinds of forest may therefore have some value beyond the project in which they were obtained for use in relation to evaporation, surface runoff, infiltration, or erosion.

Organic material above the mineral soil was sampled by cutting around areas of one square foot, measuring depth on all four sides, and collecting the organic matter. The separation of organic and mineral matter was quite easy in these types and later separation in the laboratory seemed unnecessary. The 8 to 70 sampling points in each type were located systematically in the earlier and randomly in the later years. Trends with age were not evident in the stands over 30 years old, where sampling was repeated in the years from 1940 to 1953 so that data of different years were combined as bases for the averages. Dry weights were determined by drying subsamples for 24 hours in an oven at 100° C. Volume weight was computed as the ratio of dry weight to the weight of an equal volume of water. Field moisture capacity was determined as the moisture retained after immersion in water for 72 hours followed by draining over dry mineral soil for 48 hours in cylinders with cheesecloth separating organic material and mineral soil. Cylinders were sealed at the top to prevent evaporation. Field moisture capacity is expressed as a percentage of dry weight.

The plantations of Table 1 and also the coast live oak and grass of Table 2 were located on 30 to 40 percent slopes with clay loam soils at Berkeley. The stands of Table 2, excepting the live oak and grass, represent typical types of the west slope of the Sierra Nevada and two plantations of Coulter and Knobcone pine from the chaparral region of southern California, all on gentle slopes with sandy loam soils derived from igneous rocks.

Data for six of the plantations in Table 1, when they were 30 years old, were reported in 1940 (*5*). The dry weights correspond closely to those found 10 to 15 years later except for Canary pine which increased from 12.6 to 22.2 metric tons per acre. The forest floors and upper mineral horizons of the mature ponderosa and sugar-ponderosa pine types were characterized earlier as to depth, structure, pH, and loss on ignition of the L, F and H layers (*2*). Depths of the A horizon in 1938 were 3.1 inches for the ponderosa pine and 1.5 inches for sugar-ponderosa pine compared with 1.3 and 1.2 inches found in this study. The volatile matter of the forest floor of 150-year-old ponderosa pine on the Sierra National Forest amounted to 19.2 metric tons per acre at 4,000 feet, 51.1 at 5,000, 35.3 at 6,000, and 50.0 at 7,300 feet elevation (*4*). The total floor at 5,000 feet including non-volatile matter was 76.1 metric tons per acre. The sugar-ponderosa pine-fir 50 years old at 5,000 feet had 58.5 metric tons per acre and even old lodgepole pine at 9,800 feet had 44.8 metric tons per acre, volatile matter. These samples were collected 6 feet from the stems and were therefore doubtless under the crowns. However, the amounts are larger than those to be reported presently. Dry weight of 27.6 metric tons per acre from the pine-fir

TABLE 1.—FOREST FLOOR OF PLANTATIONS 30 TO 43 YEARS OLD AT BERKELEY, CALIF.

	Monterey pine	Canary pine	Deodar cedar	Blue gum	Maritime pine	Madrone	Redwood	Christmas berry
Median dry weight, metric tons per acre	25.0	22.2	17.6	15.0	13.8	11.9	10.6	5.1
Median depth, inches	3.1	4.5	2.8	1.6	2.6	2.3	2.0	1.0
Median volume weight	0.06	0.05	0.08	0.06	0.05	0.07	0.07	0.06

TABLE 2.—AVERAGE OVEN-DRY WEIGHT PER ACRE, DEPTH AND FIELD MOISTURE CAPACITY OF FOREST FLOOR IN DIFFERENT FOREST TYPES

Forest type	Dry weight			Depth			Field moisture capacity
	Stand	Under crowns	In openings	Stand	Under crowns	In openings	
	Metric tons per acre			*Inches*			*Percent*
Immature white fir, near Pinecrest, 5,200 feet	27.7	30.2	5.4	1.4	1.5	0.1	161
Mature red fir, near Pinecrest, 6,260 feet	22.2	23.5	17.2	1.3	1.4	0.9	179
Mature white fir, near Pinecrest, 5,200 feet	20.9	20.9	21.1	1.3	1.3	1.3	183
Bigtree, over 1,000 years old, Sequoia Nat. Park, 6,500 feet	----	26.1	----	----	----	----	----
Mature ponderosa pine, near Pinecrest, 5,200 feet	19.4	25.8	15.1	1.3	1.7	1.0	173
Mature sugar-ponderosa pine, near Pinecrest, 5,580 feet	18.3	33.5	8.1	1.2	2.0	0.5	169
Mature coast line oak, Berkeley, 700 feet	11.1	----	----	2.1	----	----	159[1]
Knobcone pine, 15-20 years old, San Dimas Expt. For., 2,850 feet	9.9	----	----	1.7	----	----	206
Coulter pine, 20-25 years old, San Dimas Expt. For., 2,850 feet	8.5	----	----	1.3	----	----	202
Ponderosa pine, 14 feet high, near Pinecrest, 5,200 feet	8.1	7.4	10.6	0.7	0.6	0.9	176
Grass, Berkeley, 800 feet	1.7	----	----	1.0	----	----	245[1]

[1]Determinations by an approximate method.

type was reported on the Stanislaus National Forest near the present study area and 27.8 from pine-fir-cedar near Placerville (*7*). Ponderosa pine on the Lassen National Forest at 6,000 feet had forest floor of 11 and white fir, 21 metric tons per acre. Mature Douglas-fir near Wind River, Washington had 29 metric tons per acre of forest floor (*3*). Bigcone Douglas-fir at 4,700 feet on the San Dimas Experimental Forest had 10.1 metric tons per acre of floor with field moisture capacity of 167 percent (*6*).

The plantations of Table 1 were of the same age with the exception of the blue gum which was 5 years older. They grew on the same Los Osos clay loam although the Canary pine and blue gum (*Eucalyptus globulus*) were on the south exposure in grassland and the other species on the north exposure characterized by coast live oak, California laurel, hazelnut, and coffeeberry. The differences in forest floor are therefore attributable to the differences in species. Monterey and Canary pine are the two that deposit the deepest and heaviest layers of forest floor, more than 3 inches deep and over 22 metric tons per acre. Redwood had only 2 inches of floor with dry weight of 10.6 metric tons per acre. Christmas berry, hardly more than a shrub, was the lowest with 1.0 inch of floor. Blue gum with 15 metric tons per acre, 1.6 inches in depth, had a much heavier floor than was apparent from casual observation of what looked like a sparse layer of litter.

Average volume weights varied only between 0.05 and 0.08, the former in the Canary pine and madrone of which the large needles and leaves do not pack closely and the latter in the blue gum and deodar cedar. Blue gum floor has a large proportion of twigs, bark and capsules that add to its density and deodar needles form quite a dense mat.

Field moisture capacities were determined for only three of these types, namely Douglas-fir, 150 percent, Canary pine, 182 and Monterey pine, 186 percent. The retention storage depths (the product of field moisture capacity/100 $\times$ volume weight $\times$ depth of floor) for these two pines are 0.41 and 0.35 inch respectively, an appreciable retention of rainwater most of it subject to loss by evaporation.

The dry weight of forest floor (W) is obviously related to its depth (D) and for Monterey pine, the relation can be expressed as $W = 6.6\,D + 3.5$. The regression coefficient is highly significant and can be interpreted by the statement that dry weight increases 6.6 metric tons per acre as depth increases 1 inch. However, estimates of dry weight by this equation would be only approximations. For redwood with only 17 samples, the regression, $W = 1.9\,D + 7.6$, was not significant. However, the comparison with the equation for Monterey pine suggests that there may be wide differences between species in the relations of dry weight and depth.

The 20-year-old plantations of Coulter and Knobcone pine in southern California in Table 2 have 8.5 and 9.9 metric tons per acre of floor, somewhat smaller than the coniferous plantations at Berkeley. The difference however may be one of age rather than of species. The dense natural stand of ponderosa pine 14 feet high and 28 years old on the Stanislaus National Forest had 8.1 metric tons per acre of floor only 0.7 inch in depth, doubtless a reflection of the slow growth and small size of the trees. Only the grass with 1.7 metric tons per acre had lower dry weight but the grass litter decomposes almost as fast as it accumulates. The stand of coast live oak had the greatest depth of floor, 2.1 inches, but only 11.1 metric tons per acre dry weight, an example of litter of hard leaves that do not pack closely. The other types of mature timber on the west slope of the Sierra Nevada had surprisingly similar forest floors of depths between 1.2 and 1.4 inches and dry weights between 18.3 and 27.7 metric tons per acre. The largest amount in the immature white fir was probably attributable to the denser stand that was nearer the age of culmination of growth. The relation between dry weight and depth is apparent in the averages for the different types.

The dry weights and depths in Table 2 have been segregated for the Pinecrest samples into two categories, one for samples from under the crowns of the trees, the other for samples in the openings between the crowns. In four out of six of the types, the amounts of floor were greater under the crowns and in the immature white fir, more than 5 times as great as in the openings. Presumably the difference between the two categories should increase with the size of the openings but this tendency appears only in the sugar-ponderosa and mature ponderosa pine types. The higher values in the openings of young ponderosa pine and mature white fir are doubtless related to locations of samples close to the edges of the crowns.

The field moisture capacities or retention storage in percent of dry weight varied for the Sierra types only from 161 in the immature white fir to 183 in the mature white fir. The Knobcone and Coulter pine with 206 and 202 percent were somewhat higher but still within the usual range for such data. The grass litter with 245 percent is much the highest as is usually the case in comparison with woody vegetation. However, the volume weight for grass is low, between 0.02 and 0.03, and consequently the depth of retention storage is relatively low. For example, $245/100 \times 0.02 \times 1.0$ equals 0.05 inch depth of water, far below the 0.4 inch derived previously for the pines.

Almost all of the foregoing figures are quite similar in magnitude to those that have been reported previously and all for averages of stands are well above the 0.5 inch depth of floor of Monterey pine that has been suggested as a minimum to prevent accelerated erosion (*8*). The danger of erosion would not be a problem in stands of these densities and ages, unless they were considerably reduced in density by cutting. By moderate

cuttings, it should be possible to reduce the losses of water by evaporation from the forest floor without accelerating erosion. The cuttings would result in smaller depths of forest floor and consequently in reduced retention storage subject to evaporation. The same result might be obtained by controlled burning under conditions when only the upper layer of the floor would be consumed. Such silvicultural treatments would be advantageous in watershed management where larger yields of water are important.

Summary

The findings may be summarized in a few statements.

All of these plantations and stands had ample forest floor to prevent accelerated erosion. Monterey and Canary pine produced as much or more in 40 years than was found in mature fir and pine forests of the Sierra Nevada.

Volume weights of forest floor in the different forest types varied only between 0.05 and 0.08.

Field moisture capacities were all between 150 and 206 percent excepting grass with 245 percent. Retention storage of Monterey and Canary pine was about 0.4 inch.

Losses of water by evaporation from the forest floor could be reduced and yields of water increased by thinnings and partial cuttings which would reduce amounts of forest floor but not sufficiently to cause accelerated erosion.

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