

CHAPTER XII

FOG DRIP

In foggy weather in coastal fog belts like that occupied by the redwood, or in the mountains among the clouds, the dripping of water from the foliage of trees is a common phenomenon. The term "fog drip," including "cloud drip," is simple and expressive, although the phenomenon has also been referred to as "occult condensation" and as "horizontal precipitation." The process results from the deposition of small drops of atmospheric moisture moving horizontally by contact on the surfaces of the foliage, where in time they combine to form larger drops that run off and fall to the ground. The contributions of water by fog drip have been given little study and are apparently widely variable in different regions and localities. Swiss and French observations have indicated discharges of streams larger than the amounts of precipitation falling on the drainage basins and the excesses were attributed to occult condensation.

62. Relation to Interception.—Fog drip, inasmuch as it represents measurable precipitation under the tree crowns when none is collected in the open, may be considered as negative interception. In other words the interception in any area will be subject to a reduction for any fog drip that may be caught beneath the trees. This phenomenon may be illustrated by figures recorded by Moore (258) in New York where, during the summer season, the computed interception for a hardwood-hemlock forest was 3 per cent but after eliminating days with fog amounted to 11 per cent. Similarly, in a pure stand of hemlock the total interception amounted to 9 per cent, whereas, omitting days with fog, it became 13 per cent. In stands of *Abies firma* in Japan at an altitude of 1,566 m, during two foggy months Hirata (154) recorded excesses of 10 and 11 per cent for the catch of rainfall under the forest as compared with that in the open, that is, negative interception.

63. Experimental Measurement.—Fog drip has been measured experimentally several times. In South Africa 3-in. rain gages, one with reeds projecting 1 ft above the gage and so arranged that moisture deposited upon them would run into the gage, caught 79.8 in. in the period from December to February while an ordinary gage caught 4.9

in. A repetition of the experiment by Phillips (285) at an altitude of 1,725 ft used 5-in. gages in which branchlets of broad-leaved conifers were arranged in wire frames projecting 12 in. above the gages. In the period from June to May the control gage caught 52.0 in. and the gage with the vegetative screen 94.6 in., or 182 per cent as much. The excess of the screened gage was recorded in every month except February, when the rainfall was predominantly normal showers and heavy downpours. In the other months most of the precipitation came as fine misty rains that are likely to give a subnormal catch in an unshielded gage at the same time that they contribute to fog drip. It was pointed out in comment on the foregoing experiment that the result was caused largely by the small size of the gage and the relative importance of cutting off the normal fall of the drops to leeward of the gage. Thus the percentage of excess should be greatest when the ratio of wind velocity to rate of fall of the raindrops is greatest. The same reasoning applies also to trees and the fog drip from them.

In Maryland, DeForest (109) repeated the experiment using 3-in. gages, one with a wire screen and one with a wire screen supplemented by artificial reeds of tin bent lengthwise at an angle of 135 deg. With natural rains the screened gages gave an excess over the normal of about 30 per cent. Several hundred tests with artificial rains gave excesses from 1 to 85 per cent, and the excess tended to increase with the rainfall.

An extension of the same idea has been used as the basis for a fog meter by Rubner in Germany (303). He arranged series of vertical aluminum rods 1 m long above the orifices of rain gages. One gage had 56 rods with a surface area equal to one-third of the horizontal area of the orifice. Another had 28 rods so that the ratio of surface to horizontal was one-sixth. On the basis of records from April to November for 6 years the average seasonal catch of fog drip in the gage with 56 rods was 3.5 mm and in that with the 28 rods, 2.0 mm. He considered that the relation between 3.5 and 2.0 was sufficiently close to that between one-third and one-sixth that fog drip could be considered to be directly proportional to the ratio of surface to horizontal area. Under a spruce forest on foggy days the daily catch of fog drip was from 0.1 to 0.3 mm or from two to twenty-four times that in the fog meter. In this forest the ratio of leaf area to ground area varied from 4 to 19 with an average of 8. Since 8 is to $\frac{1}{3}$ as 24 is to 1, the proportionality of fog drip to the ratio of vertical to horizontal area was confirmed. He concluded that, as a result of fog drip, the precipi-

tation under forest cover in foggy weather might exceed that in the open by from 30 to 50 per cent.

Similarly, 4 years' records at 2,500 ft elevation in the Taunus Mountains by Linke (222), where there are some 200 foggy days each year, showed a gage catch near the edge of the forest averaging 157 per cent of that in the open, and toward the interior 123 per cent. The maxima were 300 and 260 per cent, respectively.

64. Magnitudes and Relations.—The differences in the soil-moisture content of samples of the surface foot of soil under the trees and in the open in the hills east of Berkeley, California, on July 31, 1927, were ascribed by Means (244) to fog drip from the trees on the western exposure toward the ocean fogs. Under plantations of Monterey pine and eucalyptus 15 to 20 ft high at 1,600 ft above sea level, the percentage soil-moisture content under the trees varied from 22.9 to 28.5, and 10 ft from the trees in the open, from 7.7 to 9.4. The difference would be equivalent to from 2 to 3 in. of water. Obviously evaporation and factors other than fog drip would affect such a comparison of soil moisture, but the common observation of wet places on the banks and puddles in the road under the trees after foggy nights would indicate that a part of the large difference was actually attributable to fog drip. More recently rain gages under a plantation of Canary pine at about 800 ft elevation on the same west slope have never yielded more than 0.01 in. of fog drip in rainless periods. This suggests that fog drip on the windward side of ridges becomes increasingly important toward the crests. Confirmation is found in the records taken on Mt. Wilson in southern California, and summarized in Table 19.

The gages were on the summit of the mountain where the trees were fully exposed to the fog and cloud-bearing winds from the south and southeast. The records under the trees represent the resultants of interception when rain or snow fell from clouds above the mountain and fog drip either with or without rain when the clouds or fog extended to and below the crest. Under the low-crowned *Ceanothus* (*C. leucodermis* Greene), fog drip and interception were nearly equal. The fog drip increased to 25 and 38 in. as the height of the trees increased to 40 and 80 ft. In other words the fog drip is a function of the length of crown exposed to the horizontally moving droplets of fog. Under the 80-ft pine the fog drip was twice as great under the leeward as under the windward side of the tree, presumably because the wind moved the drops to leeward as they fell. These results are probably extremes only representative of the top of the mountain.

At 2,500 ft elevation at Henninger Flats, also on the south slopes of Mt. Wilson, records¹ by the Los Angeles County forestry department in 1930 and 1931 showed excess of fog drip over interception in only two out of six gages under pines and cedars 30 to 40 ft high. The fog drip in these two did not exceed 12 per cent of the precipitation in contrast with the more than 100 per cent excess on the crest.

Another example of the amount of water that fog drip may add to the soil comes from the Cascade Head field station of the Pacific Northwest Forest Experiment Station.² Under a dense stand of Sitka

TABLE 19.—FOG DRIP UNDER VEGETATION AT 5,850 FT ALTITUDE ON MT. WILSON, CALIFORNIA

Location and cover	Gage catch,* in.	Fog drip, in.
October to May, 1916-1917		
Open.....	22.81	0
Under dense ceanothus, 8 ft high.....	22.67	0
Under dense canyon live oak group, 45 ft high.....	47.74	24.93
Under bigcone spruce, 40 ft high.....	48.05	25.24
Under ponderosa pine, 80 ft high.....	60.53	37.72
January to May, 1918		
Open.....	27.23	0
Under ponderosa pine, S side, windward.....	52.51	25.28
Under ponderosa pine, E side, windward.....	56.62	29.39
Under ponderosa pine, N side, leeward.....	85.38	58.15
Under ponderosa pine, W side, leeward.....	87.50	60.27

* Records furnished through the courtesy of the late W. P. Hoge and reproduced with the permission of the Mt. Wilson Observatory.

spruce and western hemlock 85 years old, near the Oregon Coast, in 18 weeks aggregating 142 days from May, 1940, to December, 1941, the excess of fog drip over interception averaged for three rain gages under the trees was 11.23 in. The rate of excess averaged 0.08 in. per day. The precipitation in the open for the same 142 days was 25.19 in., so that the 11.23 in. of fog drip represented a 44.6 per cent excess. In a single week when the gages in the open showed only 0.01 in., those

¹ Unpublished data furnished through the courtesy of the Department of Forestry of Los Angeles County.

² Unpublished data furnished through the courtesy of T. T. Munger, Pacific Northwest Forest Experiment Station, U.S. Forest Service.

under the trees caught 0.78 in. Thus fog drip may be a major source of moisture on ridges near the coast in the Sitka spruce and redwood regions.

65. Fog Drip: Summary.—1. In regions of frequent fogs or fine misty rains, as near oceans and in some mountains and mountain valleys, fog drip may at certain seasons increase the precipitation reaching the ground by amounts up to two or three times the precipitation in the open.

2. The amount of fog drip increases with the elevation of the crowns above the ground, with the area of vertical exposure of foliage surface, and with ratio of foliage to ground area.

3. The amount of fog drip from isolated trees is greater on the leeward than on the windward side.

4. In forests it is greatest near the coastal or windward edge and decreases toward the interior.

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FOREST INFLUENCES

*The Effects of Woody Vegetation
on Climate, Water, and Soil, with Applications
to the Conservation of Water and the
Control of Floods and Erosion*

BY JOSEPH KITTREDGE

*Professor of Forestry
University of California*



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