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SOME OBSERVATIONS ON PRECIPITATION MEASUREMENT ON FORESTED EXPERIMENTAL WATERSHEDS

Measurement of precipitation on forested experimental watersheds presents difficulties other than those associated with access to and from the gages in all kinds of weather. For instance, the tree canopy must be cleared above the gage. The accepted practice of keeping an unobstructed sky view of 45° around the gage[1] involves considerable tree cutting. On a level area, trees 30 feet tall around a gage require an opening of about 0.06 acre, and trees 60 feet tall, 0.25 acre; on slopes, the openings required can be much greater. Once cleared, the opening immediately begins to close — almost surreptitiously — so that periodic maintenance is necessary.

Still another problem is the effect of heavy cutting, as a watershed treatment, on precipitation catch. Other concerns are the effect of slope on the catch and whether or not the use of tilted gages for slope correction is justified. Some recent experiences along lines of these last two problems are described below. They are based on work at the Fernow Experimental Forest in West Virginia and at the Hubbard Brook Experimental Forest in New Hampshire.

Precipitation Before and After Watershed Treatment

The watershed-research program at the Fernow Forest required the commercial clearcutting of a 74-acre experimental watershed. Everything salable was removed and only isolated unmerchantable trees were left. The clearcutting exposed the two precipitation gages (standard cans) to

[1] Pereira, H. C., McCulloch, J. S. G., Dagg, M. and others. ASSESSMENT OF THE MAIN COMPONENTS OF THE HYDROLOGICAL CYCLE. East African Agr. and Forestry Jour. 27: 8-15, 1962.

Table 1. — *Reduction in precipitation catch after cutting Watershed 1, Fernow Experimental Forest*

Gage No.	Period	Decrease in catch	
		Inches	*Percent*[1]
11	Annual	1.8	2.9
12	Annual	1.6	2.8
11	December-April	1.5	6.9
12	December-April	.6	3.3

[1] Decrease as percentage of the predicted annual or seasonal value.

Table 2. — *Effect of shielding on precipitation catch, Hubbard Brook Experimental Forest*

Period	Shielded	Unshielded	Difference
	Inches	*Inches*	*Percent*
Growing season 1959	20.31	20.14	0.84
Growing season 1960	25.66	25.68	— .01
Dormant season 1959-60	37.12	34.87	6.45

much greater wind movement and consequently reduced the precipitation catch.

The amount of reduction during the 6-year calibration period was determined by regressing annual and dormant-season catches of each of the two watershed gages — gages 11 and 12 — to gage 14, which was outside the treated area; then the regression was used to predict the expected catch in gages 11 and 12 over the 4-year treatment period. Reductions in catch are shown in table 1.

Timber cutting reduced annual catch by a little less than 3 percent, and the December-through-April catch by 3 to 7 percent. The greater winter differences can be attributed to snowfalls because snow catch is affected more by gage exposure than rainfall catch is.

Similar results were obtained at the Coweeta Hydrologic Laboratory in the southern Appalachians where practically all the precipitation fell as rain. A clearing of two watersheds caused a yearly decrease in catch at three gages of 0.98, 3.06, and 4.14 inches, or 1.4, 4.5, and 6.0 percent respectively. The two largest decreases were statistically significant.[2]

Pertinent to these results is a 3-season comparison of shielded and unshielded gage catch at the Hubbard Brook Experimental Forest in an

[2] Data provided by John D. Hewlett, Coweeta Hydrologic Laboratory, Southeastern Forest Experiment Station.

opening on one of the experimental watersheds. Here shielding had little or no effect on the rainfall catch but increased the snowfall catch by more than 6 percent. Growing- and dormant-season results are given in table 2.

What can one conclude from this? First, that in forest openings windshields should be used if winter precipitation includes significant amounts of snow; second, that windshields should be employed for more accurate rainfall catches when a heavy cutting treatment is planned.

Tilted Gages

Tilted gages for more accurate precipitation catches have been suggested by several workers, most recently and cogently by Hamilton.[3] These gages are tilted (or cut) so that the orifice is parallel to the general slope on which the gage is located. The theory behind this is that the ellipse formed by the angled cut will give a more accurate catch of precipitation that strikes the slope. If the prevailing wind direction during periods of precipitation is into the slope, a tilted gage will have a greater catch than a vertical one; however, if winds come from the opposite direction, the vertical gage will catch more. For calculating true precipitation (the amount that would be received on a horizontal surface), the catch from a tilted gage must be divided by the cosine of the slope angle.

[3] Hamilton, E. L. Rainfall Sampling on Rugged Terrain. U. S. Dept. Agr. Tech. Bul. 1096, 41 pp., illus., 1954.

Table 3. — *Percent increase or decrease of precipitation catch in tilted gages as compared to vertical gages*

Hubbard Brook Experimental Forest, West Thornton, N. H.	Fernow Experimental Forest, Parsons, West Va.[1]	Coweeta Hydrologic Laboratory, Franklin, N. C.[2]	San Dimas Experimental Watershed, Glendora, Calif.[3]
[4]1.3	—0.2	0.7	15.6
[4]3.1	—2.5	—1.6	15.1
[5]2.1	— .3	—3.9	20.8
—	— .5	—3.5	11.8
—	—	—5.3	—
	Percent slope		
24	20-42	38-82	40-105

[1] January-September at 4 sites.
[2] April-September at 5 sites; unpublished data, Southeastern Forest Experiment Station, Asheville, N. C.
[3] Four hydrologic years (October-September), each an average of 22 sites; Hamilton, E. L., Rainfall Sampling on Rugged Terrain. U. S. Dept. Agr. Tech. Bul. 1096, p. 22, 1954.
[4] Growing season (May-October).
[5] Dormant season (November-April).

Using tilted gages at the San Dimas Experimental Watershed in southern California on slopes of 40 to 105 percent, Hamilton found that catches increased 12 to 21 percent over those from vertical gages. The predominate gage aspect was southerly, the direction of most of the storms. At the Coweeta Hydrologic Laboratory and the Fernow and Hubbard Brook Experimental Forests, the effects were much less pronounced and frequently they were opposite (decrease rather than increase) from the California catches (table 3). This suggests that all but one of the Fernow and Coweeta gages were located on leeward aspects whereas the gages at Hubbard Brook were on windward situations. However, prevailing wind directions may or may not be meaningful in mountainous terrain where steep topography can cause precipitation-bearing winds to come from many directions.

What can one conclude from this? Certainly that tilting, as tried in the East, has not shown the differences found in southern California. This is probably due to location of eastern gages in small forest openings with high surrounding vegetation: reduced wind velocities cause the precipitation to fall nearly vertically into the gage. However, precipitation at gage height in San Dimas falls at greater angles to the vertical because of wind velocities attained on the exposed conditions.

The decision as to whether a vertical or tilted gage should be used involves a number of considerations. For instance, it is not so much a choice between gages as it is a choice between systems of gaging. As is well recognized, vertical gages provide an index of precipitation on the watershed. On the other hand, tilted gages, when located on representative slopes and aspects, and when exposed to strong winds, will provide an absolute estimate of total precipitation. Where the index concept is employed, substitution of a tilted gage for a vertical one would hardly be justified: it would provide only a different index.

There are other practical considerations that influence the decision. Tilted gages are more valuable when they are used in sufficient numbers to sample predominant slopes and aspects for a measure of total precipitation on a watershed — a sampling intensity perhaps beyond the resources of most research projects. To date, most watershed experiments have relied on streamflow comparisons using a control watershed rather than on precipitation-streamflow relationships. Therefore the more costly tilted-gage network may not be justified.

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