LOCAL VARIATIONS IN RAINFALL

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INTRODUCTION

The significance of local variations in rainfall may not be fully appreciated by many research workers and others interested in comparative rainfall data. Rainfall figures obtained from a single rain gauge are frequently regarded as being representative of the rainfall over several square miles surrounding the site. Great care is usually taken concerning such factors as location of a suitable level site away from trees and other obstructions, testing the rain gauges for possible flaws in manufacture and erecting them vertically, and reading the catches carefully. Despite these necessary precautions, which are taken to ensure uniformity, the observations may not be representative of the area concerned.

The results of a rainfall study conducted in England by Balchin and Pye (1) showed that, for the area under consideration, fairly large variations occurred over short distances. Twenty-seven rain gauges were used in an area of some 20 square miles in Bath and the surrounding district, and the investigators reported that altitude, aspect, wind direction, and wind speed are major factors in influencing the distribution of precipitation in this region of moderate relief. It was found that minor relief may cause significant differences in rainfall by providing a trigger effect and giving the initial lift necessary to produce rain from unstable air. The authors concluded that for such a region there is indeed a fallacy in assuming that the rainfall records of a single station are representative or typical of even a small surrounding area.

Rycroft (2) carried out a rainfall-sampling experiment in South Africa where 14 rain gauges were distributed at random over an area of only 67 acres, with the lowest gauge situated at 970 feet above sea level and the highest at 1,800 feet. The wide variation in rainfall catches between gauges located so close together led the author to conclude that the record obtained from a single rain gauge should be accepted with extreme caution. He pointed out that a valid estimate of error can only be obtained by statistical analysis of the data, which in turn should only be applied when the samples are taken at random, and that there seems to be little chance of arriving at a satisfactory estimate of the volume of water deposited on mountain catchments without using an impractically large number of gauges.

DISCUSSION

The present study was undertaken in connection with studies concerning forest fire hazard measurement and its relation to weather data. During the 1950 fire season, three-inch rain gauges of the Beall type² were set out at suitable sites in forested areas at Rattling Brook, Bishop's Falls, Newfoundland; Petawawa Forest Experiment Station, Chalk River, Ontario;

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² An inexpensive gauge having a 10-square-inch orifice and a bottle water receptacle. Blue prints may be obtained upon request from the Forestry Branch, Department of Resources and Development, Ottawa.

and the Whiteshell Forest Reserve, Rennie, Manitoba. Care was taken to locate the gauges at level sites and not closer to any object than twice the height of the object itself. They were erected vertically and the amounts of precipitation collected were measured weekly, all gauges being read on the same day.

In Newfoundland, 12 gauges were set out at intervals of about $2\frac{1}{2}$ miles along the Rattling Brook road on the forest limit of the Anglo-Newfoundland Development Company, Limited. Eleven of the gauges along the roadway, (which lies in a northwest-southeast direction) covered approximately 22 air miles, with the twelfth being located about $2\frac{1}{2}$ miles southwest of the midpoint along this road. The area is characterized by low hills, numerous streams, and small lakes. The difference in elevation between the highest and lowest gauge sites was approximately 300 feet.

Table No. 1 indicates that, for a period of eight weeks (July 31 to September 17) where the mean for the 12 gauges was 3.69 inches, the lowest catch was 3.08 inches and the highest 4.64 inches, a difference of 1.56 inches which is 34 per cent of the mean rainfall. The distance between these two gauges was only four miles and their approximate difference in elevation was 50 feet.

At the Petawawa Forest Experiment Station the records of 11 gauges, at locations selected to give the best cover of an area of some 97 square miles, also showed considerable variance. Here the gauges were separated by distances varying from one to twelve miles. The topographic features of the area are quite similar to those described above for Rattling Brook, Newfoundland. The difference in elevation between the highest and lowest gauge sites was about 250 feet. The mean rainfall for the 11 gauges for 14 weeks (June 13 to October 14) was 14.34 inches, the lowest catch being 13.37 inches and the highest 15.37, a difference of 2.00 inches (Table No. 1), which is 14 per cent of the mean rainfall. The distances between these gauges was five miles and the differences in elevation about 50 feet.

At Rennie, Manitoba, the records of 12 gauges showed a variation in rainfall similar to that of Newfoundland. Measurements were taken at sites located $2\frac{1}{2}$ miles apart along the Trans-Canada Highway, from just west of Rennie to a point some 18 miles eastward, and for 13 miles from Rennie in a northerly direction along the Brereton Lake road. The topographic features of the area are characterized by sharp, low, rocky ridges and numerous small lakes. The difference in elevation between any two of the gauge sites does not exceed 200 feet. The mean rainfall for the 12 gauges for 11 weeks (June 30 to October 6) was 5.89 inches, the lowest catch being 5.02 inches and the highest 7.09, a difference of 2.07 inches (Table No. 1), which is 35 per cent of the mean rainfall. The distance between these gauges was 14 miles.

Differences in rainfall between each gauge and every other gauge were compared to the distances between the gauges for the three localities. From Table No. 2 it may be seen that for Rattling Brook and Petawawa

TABLE No. 1

Locality	No. of Gauges	Period-Weeks	Average Distance between Gauges. Miles	Mean Total Rainfall Inches	Difference between Smallest & Greatest Catches Inches	Distance between Gauges recording Lowest & Highest Catches Miles
Rattling Brook						
Nfld.	12	8	2.5	3.69	1.56	4
Petawawa						
F. E. S.	11	14	2.0	14.34	2.00	5
Rennie, Manitoba	12	11	2.5	5.89	2.07	14

TABLE No. 2

Locality	Average Rainfall Variation Between Gauges. Inches	Regression Coefficient	Correlation Coefficient	Total Number of Differences Between Gauges
Rattling Brook				
Nfld.	.52	-0.008	-0.12	66
Petawawa				
F. E. S.	.75	0.019	0.10	55
Rennie, Manitoba	.73	0.051	0.47	66

there was practically no correlation between differences in rainfall and distance. This is indicated by the small values of the correlation coefficients which, when tested, were found not to be significant. Although the correlation coefficient for the Rennie data was much higher than for the others and in this case was highly significant at the one per cent level, the correlation is still comparatively poor. From the data at hand it is reasonable to conclude that on the whole there was no apparent correlation between distance and difference in rainfall.

Owing to numerous access roads at Petawawa, it was possible to place the gauges more evenly than was practicable at Rattling Brook or Rennie. For this reason it is felt that more reliance may be placed on the results obtained there than on those for Newfoundland and Manitoba. At Rattling Brook the area sampled was, in effect, only a narrow strip some 22 miles in length along the roadway, while at Rennie the gauges were set out in the pattern of an "L" (i.e. two strips intersecting at right angles) along the Trans-Canada Highway and the Brereton Lake road. On the other hand, the gauges at the Petawawa Station were distributed over an area approximately square in shape and so it is believed these rainfall records are probably much more representative of an area, than are the Rennie and Rattling Brook data, because in fact these latter data were not collected on an area basis, but rather only in lines laid out in particular directions.

The coefficient of determination for the Petawawa data was found to be 0.001 which indicates that only one-tenth of one per cent of the variation in rainfall may be attributed to the distance factor and from the practical standpoint this may be considered negligible. The average difference in rainfall between the various gauges was 0.75 inches, and the standard error of the estimates (in this case taken as the standard deviation of the mean) was 0.50 inches, which means that in two-thirds of the cases the difference in rainfall between the gauges was between 0.25 inches and 1.25 inches for the 14-week period. It is realized that the design of the experiment was such that broad generalizations regarding the variation of rainfall over specific areas cannot be made from the data, but nevertheless it is thought that considerable reliance may be placed in the analysis of the results obtained at Petawawa.

Generally, it was found that the shorter the observation period, the greater was the variability between the various catches at the three localities, and the smallest percentage variation occurred when the data were analyzed on a seasonal basis. It is planned to carry out further studies and to obtain additional rainfall data with a view to the preparation of analyses on the basis of short periods to show the degree of variability that may exist over comparatively short distances and which result from single rains, and the effect this variability may have on forest fire danger rating.

SUMMARY

The results of rainfall studies, carried out in Newfoundland, Ontario, and Manitoba, during the summer of 1950 by the Federal Forestry Branch, indicate that, for the areas of minor relief under consideration, large differences in rainfall often occur over comparatively short distances. The findings here substantiate in many respects those of Balchin and Pye (1) in England, and of Rycroft (2) in South Africa and indicate a high degree of variability in the catches of rainfall at sites which are separated by comparatively short distances, such as in this case, between one and twelve miles.

REFERENCES

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