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Note on the Effects of Valleys on Precipitation

By

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NOTE ON THE EFFECTS OF VALLEYS ON PRECIPITATION

By Richmond W. Longley

ABSTRACT

An examination of private precipitation records suggests that the average precipitation in a valley cut into a watershed plain is 10% higher than the average precipitation on the surrounding plain.

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RESUME

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L'examen des enregistrements de précipitation de l'Agence météorologique suggère que la précipitation moyenne dans une vallée d'une grande plaine est 10% plus élevée que la précipitation moyenne sur la plaine environnante.

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ABSTRACT

An examination of prairie precipitation normals suggests that the average precipitation in a valley cut into a widespread plain is 10 to 20 per cent below that on the surrounding plain.

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RÉSUMÉ

L'examen des normales de précipitation de Prairies suggère que la précipitation moyenne dans une vallée d'une grande plaine est de 10 à 20 pour-cent inférieure à celle de la plaine avoisinante.

Prairie	44.51 in.
Prairie River A	39.37 in.
Prairie River Valley	38.74 in.

On the basis of these 30 months, the next estimate that the precipitation at the airport is the same as that at the bottom of the valley, and both are about 10 per cent of that at Prairie.

The effects of a range of hills or mountains on precipitation have long been known. Heavy rain falls on the windward side of a mountain across the prevailing winds and, on the lee side of the mountain range, rain is below normal. The effect of another type of topography has had little attention. What is the effect of a valley on precipitation? There is a belief that convective storms follow valleys, but the evidence for such is slight.

A recent release of the Atmospheric Environment Service (Ref.) provides some information on the effects of valleys on precipitation. The area covered in the booklet is that of the three provinces — Alberta, Saskatchewan, and Manitoba. The rivers rising in the Rockies have cut deep valleys in the plains of eastern Alberta. In Saskatchewan the valleys are broader with the valley bottoms 200 to 400 ft below the level of the surrounding plains. Most of the observations are taken on the plains, but a few observing points are located in the valleys.

Table 1 provides information on one set of observations. The observing sites listed are along the Assiniboine Valley east of Regina. Some of the records go back over 50 years, but other stations are more recently established. The figures quoted are for the period 1941-1970, or for shorter periods.

The values in Table 1 show clearly that the precipitation at Fort Qu'Appelle is definitely under those on the plain 300-400 ft above the Fort. The drop is between 15 and 20 per cent with little indication that there is any seasonal variation in the decrease. Fort Qu'Appelle lies between two lakes whose heights are 1575 ft above sea level. To the north and south the land rises rapidly so that the distance between the 1800 ft contours is 1½ mi.

Another valley observing site, this one in the valley of the South Saskatchewan, is at Outlook. The old station has been taking observations for many years, but another station at Outlook was established in 1952. The bottom of the valley is at 1600 ft. The town and observing sites are about 1775 ft above sea level. The 1750 contours on the two sides of the river are 1 1/4 mi apart and the land rises gradually above this level on both sides of the river. The precipitation data (see Table 2) show a decrease of approximately 10 per cent below the amounts on the plain.

Records of precipitation were kept intermittently at Drumheller, Alberta. The town is in the valley of the Red Deer River which has cut a narrow gorge 400-500 ft below the level of the surrounding plain. The bottom of the valley is about 2250 ft above sea level. The 2500-ft contours on the two sides of the river are 1½ mi apart. Mean precipitation values for Drumheller and neighboring stations are given in Table 3. The values given suggest that precipitation in the bottom of the valley is about 20 per cent below that on the plain on either side of the valley.

The situation near Peace River gives further evidence that the valley affects the rainfall. Also, here another factor is added to the picture. Peace River Town is located near the junction of the Peace, Smoky, and Heart Rivers. The river has an elevation of 1050 ft. To the east, the land rises to 1700 ft in 1½ mi. The rise to the west is more gradual. It is 3 mi from the river to the 1700 ft contour. The land continues to rise to 2000 ft. The airport and observing site are 1866 ft, 150 ft below the level of the plain to the west. Mean precipitation values here and at four stations in the area are given in Table 4. Here the stations for comparison are farther from the base station than in the other three comparisons. On the basis of these, it again appears that the precipitation is 10 to 15 per cent less than that on the plain.

Actually, the airport is near the top of the valley, and the river runs 800 ft below the observing level. During the past 12 years, precipitation has been reported for a few months from each of four stations located at elevations between 1070 and 1225 ft. Combining these, there were 30 months of records from these four stations. The totals for these 30 months were:

Fairview	44.52 in.
Peace River A	39.37 in.
Peace River Valley	39.96 in.

On the basis of these 30 months, one must estimate that the precipitation at the airport is the same as that at the bottom of the valley, and both are about 90 per cent of that at Fairview.

DISCUSSION

In trying to assess the results presented above, one must recognize that many of the values have been adjusted by the Atmospheric Environment Service. This is understandable in view of the short and broken records from which the means have to be obtained. But the adjustments may have been such that the reported means have reduced somewhat the valley effects. Even so, the data show that the precipitation at the bottom of a valley is 10 to 20 per cent below that on the level plain. The results from the Peace River district seem to indicate that the valley effect persists up the side of the valley to the valley rim.

The observations used in this study have been made through chance in the establishment of stations. Such leaves much to be desired in drawing firm conclusions on the effect of a valley. There are many variables, such as the orientation of the valley, the variation in elevation across the valley, the effect of a sharp valley such as at Drumheller in contrast to a U-shaped valley such as found in Saskatchewan. One cannot assess the effects of these. Yet the results do provide evidence that precipitation at the bottom of a valley is less than that on level grounds.

Reference

Atmospheric Environment Service. Temperature and Precipitation, 1941-1970. Prairie Provinces. Toronto. 159 p.

44.25 in	Fairview
39.37 in	Peace River A
39.28 in	Peace River Valley

On the basis of these 30 months, one must estimate that the precipitation at the bottom of the valley is about 90 per cent of that at Fairview.

Table 1. Precipitation data at and near Fort Qu'Appelle, Saskatchewan, 1941-1970.

Station	Latitude	Longitude	Elevation (ft)	Rainfall Apr-Sept (in)	Snowfall Annual (in)	Precipitation Annual (in)	Length of Record	Type of Normal
Balcarres	50°47'	103°34'	1956	10.86	49.4	15.84	10	8
Cupar	50°47'	104°14'	1830	11.58	43.9	16.17	15	8
Edgeley	50°36'	104°02'	2100	12.38	47.4	17.21	11	8
Fort Qu'Appelle	50°47'	103°48'	1593	9.76	35.6	13.51	24	8
Indian Head CDA	50°32'	103°40'	1924	11.47	50.6	16.47	30	1
Indian Head Forestry	50°31'	103°41'	1919	11.41	42.4	15.73	11	8
Lipton	50°50'	103°47'	2023	11.24	48.0	16.17	14	8
Qu'Appelle	50°31'	103°53'	2132	12.87	53.4	18.33	—	4
Zehner	50°38'	104°24'	2240	11.56	51.6	16.92	9	8

Note: In type of normal, 1 is defined as 30 years
2 25 to 29 years
3 20 to 24 years
4 15 to 19 years
8 adjusted

Table 2. Precipitation data at and near Outlook, Saskatchewan, 1941-1970.

Station	Latitude	Longitude	Elevation (ft)	Rainfall Apr-Sept (in)	Snowfall Annual (in)	Precipitation Annual (in)	Length of Record	Type of Normal
Conquest	51°31'	107°15'	1874	10.10	38.0	14.24	12	8
Outlook	51°29'	107°03'	1774	9.28	28.8	12.52	—	2
Outlook PFRA	51°29'	107°03'	1774	9.64	31.9	13.20	18	4
Rosetown	51°31'	107°53'	1940	10.20	33.3	13.70	—	2
Strongfield	51°20'	106°36'	2013	10.39	39.6	14.43	25	8
Surbiton	51°20'	107°14'	2150	9.80	36.9	13.79	8	8

Table 3. Precipitation data at and near Drumheller, Alberta, 1941-1970.

Station	Latitude	Longitude	Elevation (ft)	Rainfall Apr-Sept (in)	Snowfall Annual (in)	Precipitation Annual (in)	Length of Record	Type of Normal
Acme CDA	51°29'	113°32'	2968	12.44	47.6	16.71	14	8
Drumheller	51°28'	112°43'	2255	8.88	36.7	12.87	—	8
Drumheller Andrews	51°30'	112°54'	2660	11.12	41.4	15.31	17	8
Hanna	51°38'	111°55'	2680	10.26	41.8	14.44	—	2
Three Hills	51°39'	113°18'	2760	11.62	39.9	15.57	—	2

Table 4. Precipitation data at and near Peace River Airport, Alberta, 1941-1970

Station	Latitude	Longitude	Elevation (ft)	Rainfall Apr-Sept (in)	Snowfall Annual (in)	Precipitation Annual (in)	Length of Record	Type of Normal
Fairview	56°04'	118°23'	2160	10.10	70.9	16.63	—	2
Falher	55°44'	117°12'	1910	10.08	61.4	16.63	15	8
McLennan CDA	55°43'	116°57'	2044	11.29	60.7	17.58	17	8
Peace River A	56°14'	117°26'	1866	8.70	57.3	13.81	17	8
Rycroft	55°45'	118°47'	1983	9.74	62.7	16.07	21	8