A DISTINCT PRECIPITATION SHADOW IN THE VALLEY OF THE SOUTH BRANCH OF THE POTOMAC RIVER, WEST VIRGINIA

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ABSTRACT

Information obtained from both current and historical climatic data indicates the existence of a well-defined "precipitation shadow" [1] in north central West Virginia. The abrupt decrease in, and lack of precipitation in a relatively narrow, elongated area in the lee of the Allegheny Plateau is possibly unique in the eastern United States.

1. Introduction

The existence of precipitation shadows is well-known throughout the world in areas where relatively high, continuous topographic barriers, perpendicular to the rain and snow producing atmospheric currents, form a barrier to the transport of moisture. These "shadows" are also known to occur in the Appalachian Mountains of the eastern United States. Here the magnitude and orientation of the topography, combined with the prevailing meteorological conditions, result in rather weak and ill-defined shadow areas. However, an exception to this pattern may be found in the valley of the South Branch of the Potomac River, West Virginia.

2. Precipitation Patterns

The isoline map of mean annual precipitation in West Virginia (Figure 1) illustrates the distribution patterns found throughout the state.

Progressing east from the Ohio River Valley (the westernmost part of the state), one sees a gradual increase, from 40 inches to 48 inches (1016 to 1219 mm), and then a rapid increase to as much as 66 inches (1676 mm) at some locations, in the central and north-central areas. As would be expected, the heavy precipitation belt lies over and just to the west (windward) of the highest elevations found in the plateau. To the east (leeward) of the plateau, marked by a scarp called the "Allegheny Front",[2] is an extremely rapid decrease in the precipitation, both snow and rain. Annual totals of under 32 inches (813 mm) may be found in this area. Progressing eastward again, precipitation begins to increase although elevations decrease. East of the mountains, at elevations of 500 feet (152 m) or less, annual precipitation levels off at about 42 inches (1067 mm).

The overall distribution patterns just described can be attributed to the fact that moisture-bearing atmospheric winds flow across the state in a generally west to east direction. This flow, being perpendicular to the high ground of the plateau, results in maximum orographic lifting of moisture-laden air and an attendant increase in precipitation. Once over the barrier, the air descends, warming up and drying out as it does so.[3] Thus, on the lee side of the plateau, one finds a precipitation shadow. The shadow may be traced both to the north into Pennsylvania and the south into Virginia, always occuring in a narrow band 25 to 50 miles (40 to 80 km) wide to the lee of the plateau. This band is roughly defined by the 36-inch (914 mm) annual precipitation isoline. The driest portions of the band lie in the valley of the South Branch of the Potomac River (Figure 2).

3. Valley of the South Branch

The South Branch is one of the largest streams that makes up the headwaters of the Potomac River. It flows from south to north for 75 miles (120 km) before joining the North Branch to form the main trunk of the Potomac. The first 30 miles (48 km) of the South Branch upstream from the Potomac. lie in a wide valley, to the lee of the plateau, but with no significant topographic barriers to the east. The upper 45 miles (72 km) of its course, from Moorefield upstream (south), lie in a more confined valley which is surrounded by relatively high mountain

[1] Precipitation shadows are more commonly called "rain shadows". However, the authors prefer the term "precipitation" since both rain and snow amounts are reduced in this shadow area.

[2] Physiographically the Allegheny Front separates the Allegheny Plateau to the west from the Appalachian Mountain Ridge and Valley province to the east.

[3] This condition is known as downslope effect.

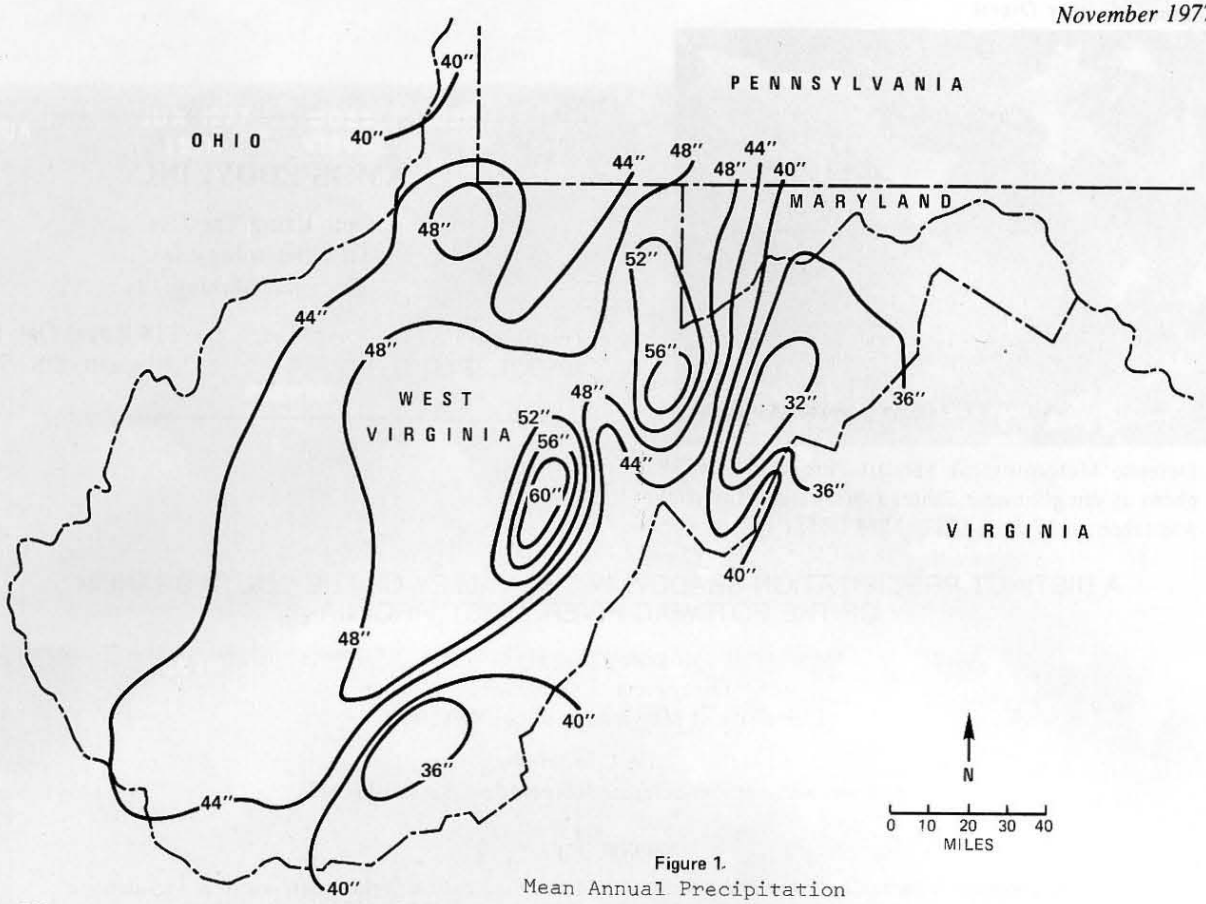

FIG. 1. Mean Annual Precipitation in West Virginia.

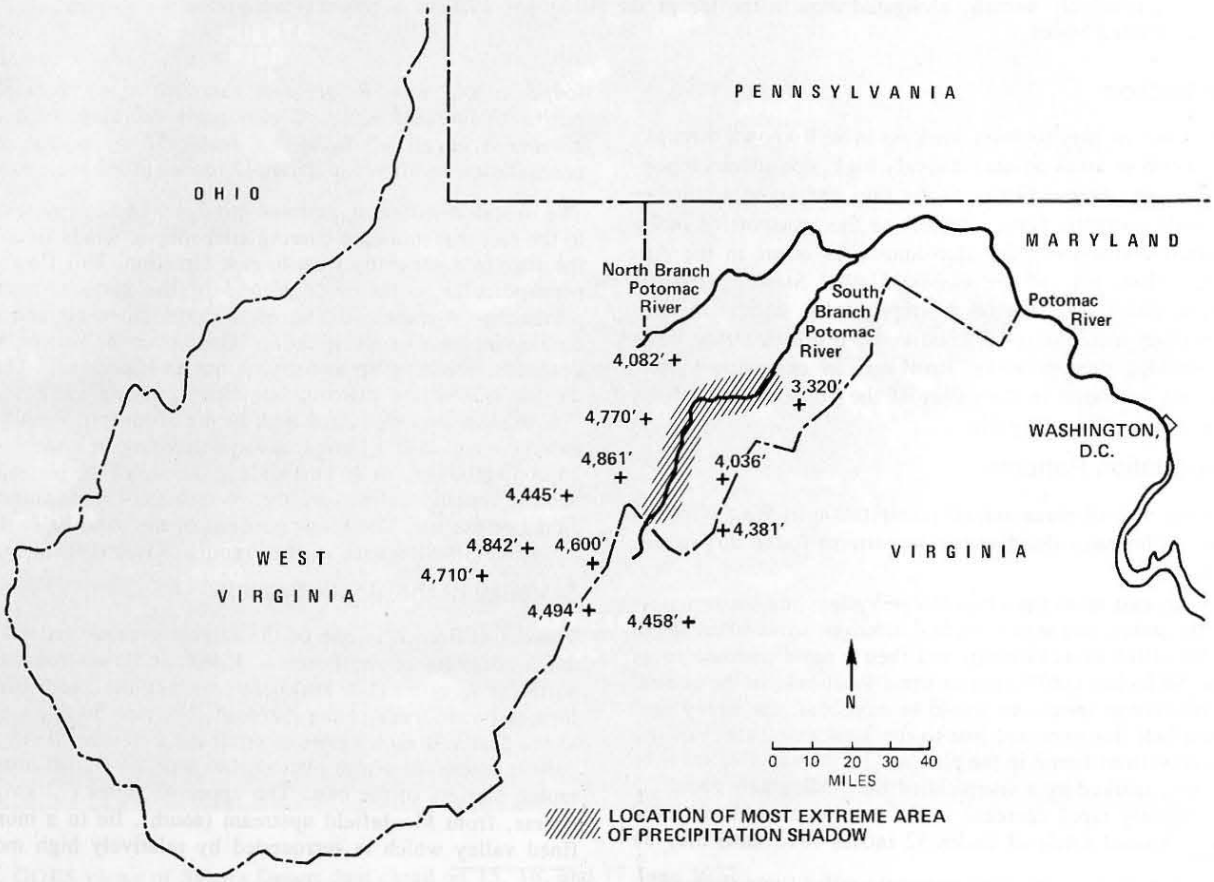

FIG. 2. Relief of the Appalachian Mountain Ridge area with the location of the precipitation shadow.

TABLE 1
Current Precipitation Records

Station	elevation	average precip. 1952-1970	maximum annual precip.	minimum annual precip.
Petersburg	1015'	29.73"	37.47"	23.83"
Brushy Run	1375'	30.01"	34.13"	21.92"
Franklin	1900'	30.58"	38.55"	23.09"

TABLE 2
Historical Precipitation Records

Station	elevation	average precip. 1899-1930	maximum annual precip.	minimum annual precip.
Moorefield	900'	31.91"	45.98"	16.84"
Upper Tract	1230'	28.82"	40.46"	9.50"

barriers. The elevations of this confined valley floor range from 850 feet (259 m) at Moorefield to 1900 feet (579 m) at Franklin, well upstream. The width of the valley floor here varies from 1 to 5 miles (2 to 8 km), and lies to the lee of Spruce Mountain and the Roaring Plains, which are the highest easternmost portions of the Allegheny Plateau (figure 3). Between the Plateau and the confined valley of the South Branch is an intermediate ridge, with elevations reaching over 3000 feet (914 m).

Both historical and current precipitation records indicate mean annual precipitation at elevations of 850 to 1900 feet (259 to 579 m) in the valley to be 29 to 31 inches—(737 to 787 mm, Tables 1 and 2). (Sites a Figure 4.) Pickens, the site of a cooperative weather station 45 miles (72 km) to the west, lies at the moderate elevation of 2700 feet (823 m) on the windward side of the plateau and receives 66 inches (1676 mm) of precipitation in the normal year. This is a 35 inch (889 mm) difference in 45 horizontal miles (72 km). It is also interesting to note that the relatively high elevation of the valley of the South Branch receives approximately 12 inches (305 mm) less annual precipitation than areas 1000 feet (305 m) lower both west and east of the mountains; even more extreme are the differences in snowfall. Based on 12 years of records, Pickens has received a mean annual snowfall of 168 inches (427 cm), but Franklin, the highest cooperative weather station in the valley, had an average catch for this period of only 31 inches (79 cm). This is a difference of 137 inches (348 cm) in 45 horizontal miles (72 km) and 750 vertical feet (229 m). Considering the elevation of the valley of the South Branch, the authors believe this area to exhibit one of the most striking precipitation shadows in the east.

4. Reasons for the Existence of the Precipitation Shadow

The following combination of factors is responsible for the abrupt decrease in and lack of precipitation in the valley of the South Branch of the Potomac River:

1. The valley lies just to the lee of one of the most extensive unbroken topographic barriers in the eastern United States. The Allegheny Plateau here stands continuously avove 3000 feet (914 m) for 120 miles (192 km) in the northeast-southwest direction, average 25 miles (40 km) in width, and is about 2500 feet (762 m) above the rolling terrain to the west. Thus, air masses traveling from west to east are forced up over the barrier. The upward movement induces cooling and enhances precipitation on the windward side of the plateau; however, the barrier is high enough and extensive enough to prevent much of the available moisture from reaching the lee side of the plateau. This is not the case in the higher but less extensive barriers such as Mt. Washington, New Hampshire, 6288 feet (1917 m). Here there is not a significant difference in precipitation amounts on the lee or windward side of the mountain because, despite its impressive vertical stature, Mt. Washington is not an extensive enough barrier to prevent precipitation from being deposited on the lee side.[4]

2. The valley is centrally located on the lee of the plateau's barrier. Therefore, the valley floor is effectively sheltered from moisture bearing winds arriving from the prevailing southwest, west, and northwest directions.

3. The valley is also "protected" from moisture bearing winds from all other directions by many miles of surrounding ridges which lie at higher elevations than the valley floor. Although not as effective at reducing precipitation as the higher and more extensive plateau, moisture advancing from these areas is not as frequent an occurrence.

FIG. 3. Looking west at the highest easternmost portion of the Allegheny Plateau, at Spruce Mountain. Relief is 3,000 feet.

[4] Occasionally, lee areas receive more precipitation than windward locations. This can occur when snow, which blows off a mountain during periods of high winds, is deposited to the lee of the peak in areas of weak or irregular air movement.

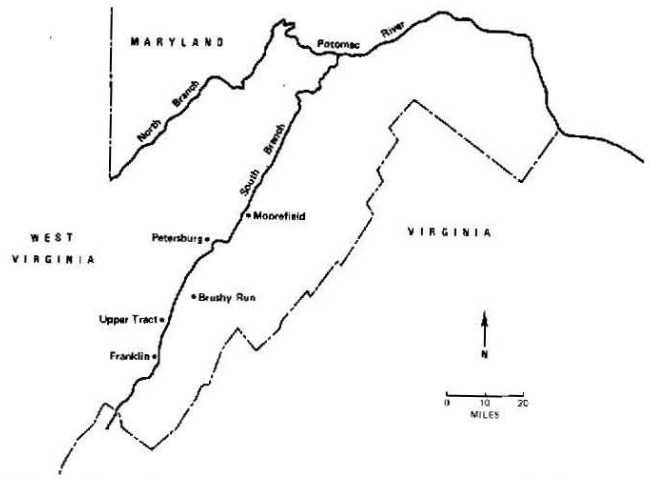

FIG. 4. Location of stations with current or historical precipitation records along the South Branch of the Potomac River.

4. The highest and easternmost scarp of the plateau, known as Spruce Mountain (Figure 4) and the Roaring Plains, lies just to the west of the valley of the South Branch. Air current approaching from the west must descend 3000 feet (914 m) before reaching the river at the valley floor. This maximum vertical descent locally enhances the downslope effect somewhat.

5. A relatively high, intermediate ridge lies between the plateau's barrier and valley floor. This intermediate barrier further depletes some of the precipitation that "spills over" the Allegheny Plateau.

As previously stated, the plateau's highest elevations are oriented in a northeast-southwest direction. With this knowledge at hand, one would expect the most pronounced downslope effect to occur when precipitation falls from relatively shallow clouds, which are traveling perpendicular to the high ground orientation. This happens frequently during the winter months when arctic air masses pass over the area on their track eastward. This was the case in January, 1977, when there was an unusually persistent northwesterly flow of frigid arctic air. In this area, January had a monthly mean temperature 15°F (9.4°C) below normal with below normal melted precipitation but above normal snowfall, the latter being especially true in the highest elevations of the Allegheny Plateau. Both the melted precipitation and snowfall differences between the high plateau and the valley of the South Branch were remarkable. The high plateau received about 3.5 inches (89 mm) of melted precipitation and 55 to 80 inches (138 to 203 cm) of snow. The valley received less than one-half inch (13 mm) melted precipitation and 7 inches (18 cm) of snow. It should be emphasized again that the valley of the South Branch lies at a relatively high elevation but it received less snow and total precipitation than areas both to the west and east at significantly lower elevations. Even sea level areas to the east received over double Franklin's total precipitation and about equal amounts of snowfall.

It is also interesting to note that while some of the normally snowiest areas of the high plateau experienced the deepest snow cover ever recoreded (Canaan Valley 68 inches (173 cm) on the last day of the month), the sheltered valley of the South Branch, only 8 miles to the east, recorded a maximum cover of only 6 inches (15 cm).

5. Conclusions and Summary

A very pronounced precipitation shadow exists in the valley of the South Branch of the Potomac River, to the lee of the Allegheny Plateau in north-central West Virginia. The existence of this distinct precipitation shadow is due mainly to its leeward location behind a relatively high, extensive, and continuous topographic barrier. The abrupt decrease in, and lack of precipitation in this area is possibly unique in the eastern United States.

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