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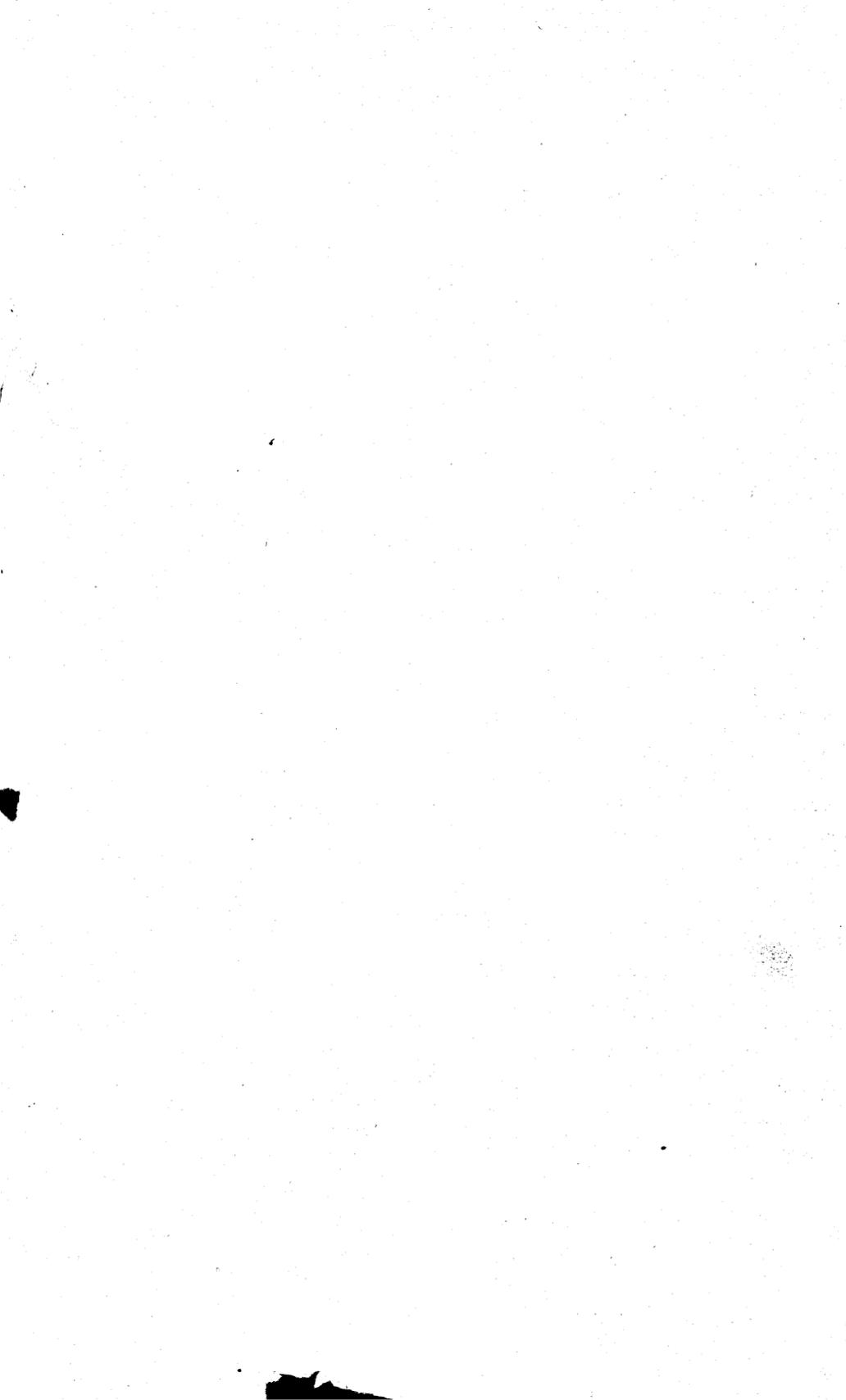
UNITED STATES GEOLOGICAL SURVEY

No. 62

HYDROGRAPHY OF THE SOUTHERN APPALACHIAN
MOUNTAIN REGION, PART I.—PRESSEY

WASHINGTON
GOVERNMENT PRINTING OFFICE

1902



UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

HYDROGRAPHY

OF THE

SOUTHERN APPALACHIAN MOUNTAIN REGION

PART I

By HENRY ALBERT PRESSEY



WASHINGTON
GOVERNMENT PRINTING OFFICE
1902

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LETTER OF TRANSMITTAL.

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
DIVISION OF HYDROGRAPHY,
Washington, D. C., December 18, 1901.

SIR: I have the honor to transmit herewith a manuscript prepared by Mr. H. A. Pressey, one of the hydrographers of this Survey, relating to the Southern Appalachian mountain region. This is the outcome of systematic measurements of the water supply from this area and of special investigations made in connection with a general inquiry as to the importance of the streams in the development of the country.

There has been a widespread movement for the acquisition by the Government of the forested lands within the Southern Appalachians and the setting aside of these as a reserve similar in character to the great forest reservations existing in the West. In this popular movement Prof. J. A. Holmes, State geologist of North Carolina, has been especially active. He has been cooperating with this Survey in all matters pertaining to the investigations in North Carolina, and has been the representative of the State in arranging for the disbursement of funds made available by the State for extending the systematic work carried on in that region. At his suggestion and with his active assistance the surveys and examinations described by Mr. Pressey have been made.

The importance of a full knowledge of this region is apparent when we consider the size and number of the streams issuing from this central mountain area. Water-power development, especially in the manufacture of cotton, is proceeding rapidly, and there is no portion of the country for which definite official data upon the water resources are more frequently required than for this area. I recommend, therefore, that the material prepared by Mr. Pressey be published in the series of Water-Supply and Irrigation Papers, as Nos. 62 and 63 of that series.

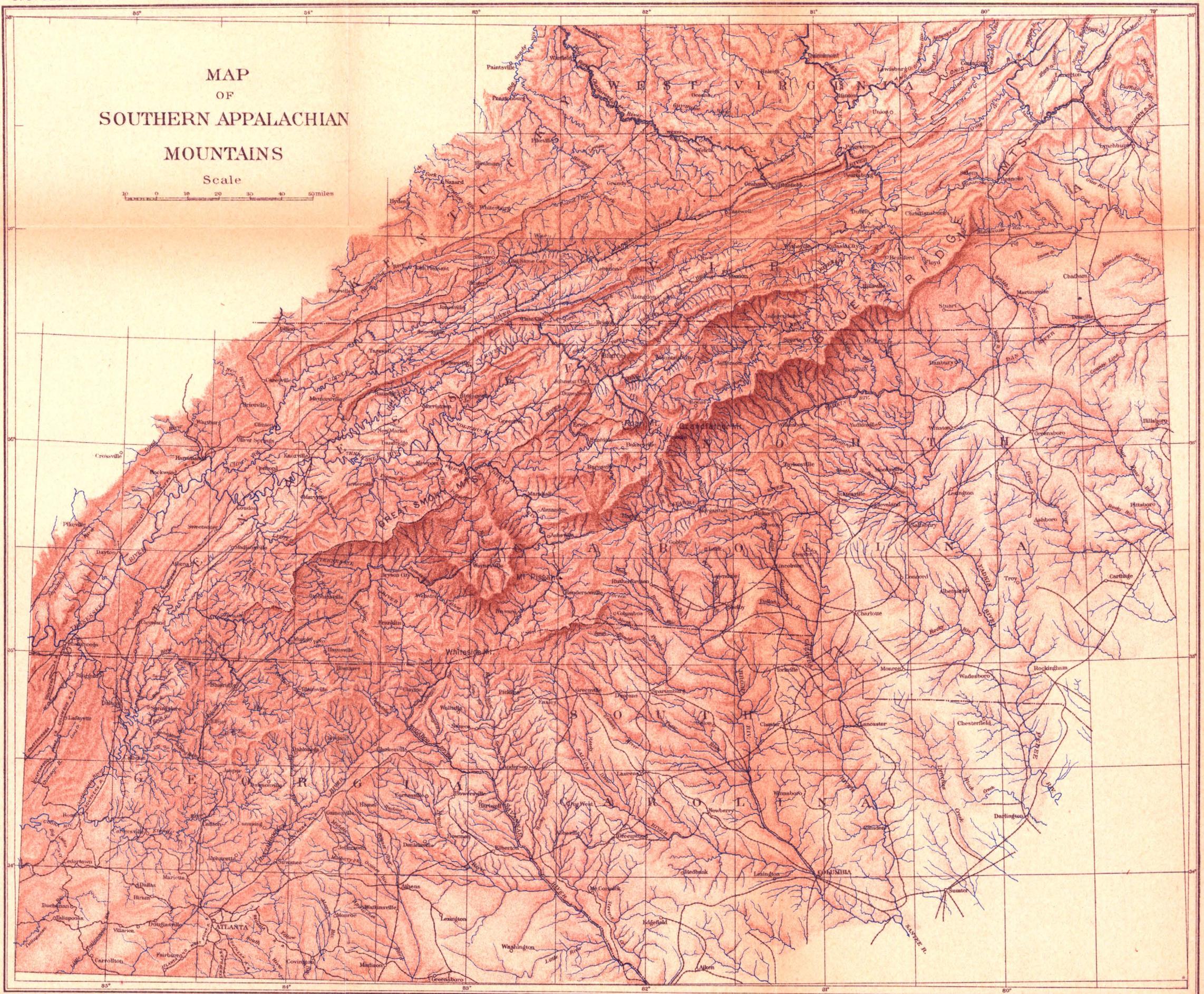
Yours respectfully,

F. H. NEWELL,
Hydrographer in Charge.

Hon. CHARLES D. WALCOTT,
Director United States Geological Survey.

MAP OF SOUTHERN APPALACHIAN MOUNTAINS

Scale
0 10 20 30 40 50 miles





HYDROGRAPHY OF THE SOUTHERN APPALACHIAN MOUNTAIN REGION.

PART I.

By HENRY A. PRESSEY.

INTRODUCTION.

The region herein described occupies portions of the States of Virginia, North Carolina, South Carolina, Tennessee, Georgia, and Alabama. It is elevated far above the surrounding country and stands out as a physiographic unit. Its rivers, topography, and resources are described in as much detail as the time available for field investigation permitted.

Special thanks are due to Mr. E. W. Myers, resident hydrographer for North Carolina and South Carolina, for his investigations and very complete reports on several of the drainage areas, the principal facts from which are embodied herein. Messrs. Cleveland Abbe, jr., L. V. Branch, N. C. Curtis, and Ernest Graves were also engaged upon the reconnaissance, and the success achieved was largely due to their assistance. The measurements of the streams to the south and west of the French Broad were under the charge of Prof. B. M. Hall, resident hydrographer for Georgia and Alabama, who was assisted by Max Hall, W. E. Hall, J. R. Hall, J. C. Conn, and H. G. Stokes. The photographs used for illustrations were taken by various members of the United States Geological Survey and of the United States Bureau of Forestry. Pls. IX and XI are from photographs by R. H. Seadin, Pls. XXXIX and XLII are by courtesy of Prof. J. A. Holmes.

GENERAL FEATURES OF REGION.

MOUNTAINS.

PHYSIOGRAPHY.

The great Appalachian mountain system stretches from Maine, in a general southwesterly direction for nearly 1,300 miles, through the States of Vermont, New York, Pennsylvania, Maryland, Virginia, North Carolina, South Carolina, and Tennessee, terminating in northern Alabama. In New York the range consists of high hills, the mountains gradually rising in elevation in Pennsylvania, where an

average height of 2,000 feet above the sea, or 1,000 to 1,500 feet above the adjacent Cumberland Valley, is reached. At Potomac River, in the vicinity of Harpers Ferry, the elevation of the peaks is again reduced to about 800 feet. From the Potomac south the ranges are much higher and broader, spreading out into the great Blue Ridge, the Shenandoah, the Allegheny, and the Greenbriar mountains, ranges with broad, fertile valleys between, of which the Valley of Virginia, or Shenandoah Valley, has a national reputation for scenic beauty and fertility. Forty-five miles below the Potomac is Mount Marshall, 3,150 feet high, and a little farther south, near Luray, are Stoneyman and Hawks Bill, 4,031 and 4,063 feet high, respectively. These are the highest summits of the Blue Ridge north of North Carolina. The ranges extend in nearly parallel lines through the States of Virginia and West Virginia, and enter North Carolina and Tennessee near their common boundary, culminating in the Iron and the Great Smoky ranges, which with numerous cross chains form the great mountain region of the Southeastern States. In this mountain mass 288 peaks exceed a height of 5,000 feet, and 27 peaks have an elevation greater than Mount Washington (6,293 feet). From North Carolina and Tennessee the ranges extend more to the westward through Georgia and into Alabama, with outlying ranges in South Carolina, and are finally lost in hills forming the headwaters of the Gulf drainage. The general features of the southern and most massive portion of the Appalachians, with the drainage, are shown in Pl. I.

This great mountain system forms the backbone and watershed of the eastern part of the United States. The greatest masses and the highest peaks are in western North Carolina and eastern Tennessee, which region may be considered a high plateau, of which the Smoky Mountains form the western boundary of the highest portion and the Blue Ridge the eastern boundary. The latter ridge extends across the State of North Carolina in a general northeast-southwest direction until it reaches the southern border of the State, when it turns to the west and for a long distance (about 40 miles) forms a part of the boundary between North Carolina and South Carolina, passing at length into the State of Georgia and meeting again the Great Smoky Range. The area of the region included between these two ranges, which approaches to almost a point at its northern and southern extremes and at its widest portion has a width of 55 miles, is approximately 6,000 square miles.

The most striking characteristic of the Blue Ridge is the great difference in slope of its opposite sides. The rivers flowing to the west into the Tennessee and the Ohio head in the gaps upon the divide and for miles flow in broad, smoothly rounded, drift-filled valleys before entering the narrow, rock-cut gorges of their lower courses, while the rivers flowing to the east plunge downward in a series of cascades, falling several thousand feet in a distance of a few miles. The latter

streams can hardly be said to have valleys, but simply V-shaped gorges, through which they tumble and foam until they reach the Piedmont Plain, which extends along the southeastern base of the Appalachian system. The surface of this plain has a general eastward slope from an altitude of about 1,000 feet at its western edge to 250 or 300 feet on the east, where it merges into the Coastal Plain.

The Smoky Mountains, on the western edge of the high plateau referred to, are extended to the north in the Bald and the Iron mountains and to the south in the Unaka Range. These mountains are much more massive and reach far greater elevations than the summits of the Blue Ridge. Many of their peaks attain heights of more than 6,000 feet. Unlike the Blue Ridge, their slopes are equally steep on both sides, their outlines are angular and rugged, and descents of 4,000 feet from the crest to the stream bed are not uncommon.

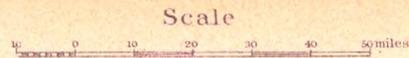
Several cross chains connect the Smoky and Blue Ridge ranges, cutting the plateau into a number of small basins, each nearly surrounded by mountains and having its own independent system of rivers and drainage, so that nowhere in this region do we find extended fertile valleys, as in Virginia and Tennessee, but instead in every direction high mountain ranges cut off the view and give it the appearance of a rocky and truly mountainous country.

The highest and most massive of the cross chains is the Black Mountains—named for their somber vegetation of balsam and other evergreens—which really consist of two chains having a united length of 40 miles and extending in a northwesterly direction from the Blue Ridge through the counties of Buncombe and Yancey and forming a connecting link between the Blue Ridge and the Smoky mountains. This range of mountains comprises 25 peaks, 18 of which are more than 6,000 feet in height. On their western slopes rise the eastern tributaries of the French Broad, the valley of which separates the Black Mountains from the Pisgah and the Newfound mountains, other of the cross chains, on the western slopes of which rise the eastern tributaries of Pigeon River. The western tributaries of the Pigeon flow from the Balsam Mountains, a range having an average elevation of 5,600 feet and comprising 23 summits with elevations exceeding 6,000 feet. This range extends from the South Carolina line to the Smoky Mountains. Still farther to the west are the Cowee Mountains, with a mean height of 4,800 feet. Rising at the southern end is Yellow Mountain, with an elevation of 5,133 feet. The last of the cross ranges to the west is the massive double chain of the Nantahala and the Valley River mountains, with a mean height of 5,000 feet. East of the Black Mountains are the Linville Mountains, through which Linville River has cut its stupendous chasm.

The Smoky and the Blue Ridge mountains, with their numerous cross chains, form the culmination of the Appalachian mountain sys-

DRAINAGE BASINS OF SOUTHERN APPALACHIAN MOUNTAINS

Showing gaging stations maintained by
U. S. Geological Survey



tem, and are the highest and most massive mountains in the United States east of the Rockies. Following is a list of the peaks which exceed in elevation 6,000 feet:

Highest peaks in Southern Appalachians.

Smoky Mountains:	Feet.
Mount Buckley	6,599
Clingmans Dome	6,660
Mount Love	6,443
Mount Collins	6,188
Mount Alexander	6,447
Mount Henry	6,373
Mount Guyot	6,636
Tricorne Knob	6,188
Ravens Knob	6,230
Thermometer Knob	6,157
Luftee Knob	6,232
Cataloochee Mountain	6,159
Roan High Knob	6,313
Roan High Bluff	6,287
Grassy Ridge (bald)	6,226
Mount Curtis	6,568
Mount Leconte	6,612
Master Knob	6,013
Oconee Mountain	6,135
Peck Peak	6,232
Mount Safford	6,535
Balsam Mountains:	
Enos Plotts Balsam	6,090
Jones Balsam	6,224
Rockstand Knob	6,002
Brother Plott	6,246
Amos Plotts Balsam	6,278
Rocky Face	6,031
Double Spring Mountain	6,380
Richland Balsam	6,540
Chimney Peak	6,234
Spruce Ridge Top	6,076
Reinhardt Mountain	6,106
Devils Court-house	6,049
Sams Knob	6,130
Cold Mountain	6,000
Mount Hardy	6,102
Jones Knob	6,209
Mount Junaleska	6,223
Rocky Trail	6,488
Water Rock Knob	6,399
Black Mountain	6,275
Shining Rock	6,040
Rough Butt Bald	6,010
Cold Springs Knob	6,010

Black Mountains:	Feet.
Blackstocks Knob (northwest chain).....	6,386
Potato Top (northwest chain).....	6,487
Black Dome (main chain).....	6,502
Mount Gibbs (main chain).....	6,608
Mount Hallback or Sugarloaf (main chain).....	6,432
Mount Mitchell (main chain).....	6,711
Balsam Cone (main chain).....	6,697
Black Brother (main chain).....	6,645
Cattail Peak (main chain).....	6,609
Hairy Bear (main chain).....	6,622
Deer Mountain (main chain).....	6,220
Bowlems Pyramid or Celo (main chain).....	6,351
Locust Mountain.....	6,088
Burnt or Long Mountain.....	6,238
Clingman Peak.....	6,611
Yeates Knob or Big Butt.....	6,001
Potato Knob.....	6,419
Patton Knob.....	6,079
Craggy Range:	
Big Craggy.....	6,106
Bull Head.....	6,072

The foregoing table shows a total of 64 peaks having elevations of 6,000 feet or higher. There are 288 peaks that exceed in height 5,000 feet, and the number that exceed 4,000 feet is much greater.

GEOLOGY.

For the following brief description of the geology of the region the writer is indebted to Mr. Arthur Keith, of the United States Geological Survey, who has made a careful study of the Southern Appalachians:

"The geologic formations which underlie this mountain district may be divided into four large groups. Each differs widely from the others in age, and has very distinct features of its own. These broad differences have expressed themselves in such major topographic features as the Appalachian Valley, the Appalachian Mountains, and the Piedmont Plateau. These differences are also largely responsible for the principal variations in the character of the surface in the mountain district itself.

"The Appalachian Valley is underlain by a series of limestones, shales, and sandstones, mainly of Silurian and late Cambrian age, forming the youngest of the four groups in this region. Small outliers of these formations are included within the area of the mountains near the border of the Appalachian Valley.

"The second group occupies the northwestern border of the mountain district, chiefly northeast of French Broad River. It consists of a series of quartzites, conglomerates, and shales of Lower Cambrian age. A second large area of these rocks occupies the Blue Ridge and adjacent territory nearly in the center of this district.

“The third group is of Cambrian age. It occupies the northwest border of the mountain mass, corresponding in position to the previous group but developed southwest of French Broad River in the Smoky and the Unaka mountains. The group consists of conglomerates, graywackes, sandstones, schists, and slates, and is called the Ocoee group. This and the preceding two groups were composed of the waste from older rocks, which was deposited under water. The thickness of the strata is approximately the same in the Ocoee group and the formations of the Appalachian Valley. The Lower Cambrian quartzites and shales of the second group have only from one-fourth to one-third of the thickness of either of the preceding groups.

“The fourth group is much the largest of all, both in actual bulk and in area. It consists in the main of formations of the Archean, or oldest known age. The different rocks include several kinds of granite, diorite, mica- and hornblende-gneiss, and various schists. A large number of these were of igneous origin, but the original nature of many of the gneisses and schists is unknown. Formations also included in this group are the ancient volcanic rocks. These are developed most prominently in connection with the Cambrian quartzites in the northeastern part of the mountain district.

“Much of the surface of the Appalachian Mountains is exceedingly ancient. During the later geologic periods it has been subjected to the various natural agencies of destruction, and has been worn down according as the rocks presented at the surface were susceptible to these influences. The materials composing these formations are attacked in varying degrees by solution and by chemical processes connected with atmospheric and underground water. Certain minerals—for instance, carbonate of lime—are readily dissolved by natural waters, and the rock in wasting away leaves behind only the less soluble portions in the form of clay. To this capability is directly due the reduction of the great valley below the level of the mountain mass. Other minerals—for instance, feldspar—are in part dissolved and in part chemically altered and decomposed by natural waters, so that the coherence of the rock which contains them is largely destroyed. Two groups in this region have a large proportion of feldspar in their make-up, and their surfaces have been gradually lowered by its breaking down. These are the Ocoee group and the Archean group. A third mineral, quartz, is comparatively little changed by solution or chemical action near the surface. Formations made up in large part of this mineral retain their altitudes most persistently, and are usually the last to be reduced. This composition is most pronounced in the Lower Cambrian group, but is shared also by the Ocoee group and the Archean group. Although the thickness of the Lower Cambrian quartzites is so much less than that of the other groups, their resistance to solution has caused them to remain upheld in very high ridges and peaks. To this are due the cliffs of the Chilhowee, Camp



ESCARPMENT OF THE BLUE RIDGE AT BLOWING ROCK, N. C.

Creek, and Iron mountains, and the rugged crags of Grandfather. In the case of the Ocoee and Archean groups their immense thickness and the amount of quartz which they contain have maintained the greatest elevations presented in this region. Of this the mighty domes of the Smokies, the Balsams, and the Roan, and the lofty peaks of the Blacks are witnesses."

RIVERS.

The region is well watered. From it several of the largest rivers of the country receive their supply. The main divide of the river systems is the Blue Ridge. This chain, which enters the State of North Carolina in Alleghany County, extends southwest between Wilkes and Ashe counties and through Watauga County. At Grandfather Mountain, which is at the junction of Watauga, Mitchell, and Caldwell counties, the chain turns more to the south, following the boundaries between Mitchell and Caldwell counties and between McDowell, Yancey, and Buncombe counties, reaching the State line in Macon County. In this ridge and its spurs, cross ridges, and foothills many of the rivers of the Southeastern States have their origin. A view of an escarpment of the Blue Ridge at Blowing Rock, N. C., near Grandfather Mountain, is shown in Pl. III. The States of Virginia, North Carolina, South Carolina, Georgia, Alabama, Tennessee, and West Virginia are partially watered by rivers rising in mountains near the North Carolina and Tennessee State line. One of the principal upper tributaries of the Ohio (the Kanawha) and one of the largest feeders of the Mississippi (the Tennessee) head in the same mountains, and the region may justly be termed one of the chief watersheds of the United States. The drainage basins of the largest rivers are shown in Pl. II.

Flowing into the Atlantic are the Yadkin, Catawba, Broad, Saluda, and Chatooga; into the Gulf are the Chattahoochee and the Coosa. New River flows to the north and enters the Great Kanawha, whose waters finally reach the Mississippi through the Ohio River. Into the Mississippi flow the waters of the Tennessee and its large tributaries—the Holston, the Nolichucky, and the French Broad. From the western slopes of the Blue Ridge flow the headwaters of the great Tennessee river system. This drainage basin has an area of about 1,500 square miles and a length of 300 miles in North Carolina, and a fall of about 1,000 feet between its source and the North Carolina and Tennessee State line. The Cheoah, the Nantahala, the Oconalufy, and the Tuckasegee, all large streams with a width of from 50 to 100 yards, join their waters to the Tennessee, and after receiving them the latter river flows through the Great Smoky Mountains in a narrow and rocky gorge. The Hiwassee joins it in Tennessee.

All of the large streams that flow to the west have the same general

characteristics, i. e., heavy, precipitous falls in the first portion of their courses, then long even flows, with but little fall, across the broad plateaus, finally cutting through the mountain ranges on the border line of North Carolina and Tennessee, where they have rapid and precipitous falls, in some cases more than 1,000 feet in a few miles.

After leaving the State of North Carolina the Tennessee flows in a northwesterly direction for about 300 miles, through the State of Tennessee, being joined by the Holston and the Nolichucky, tributaries which carry as much water as the parent stream. The Holston receives its southern branches from this same mountain region. The Watauga, one of the chief tributaries of the Holston, rises in the center of the mountain district around Grandfather Mountain, and flows in a northwesterly direction through Watauga County, with the high, steep slopes of the mountain sides on either hand, and with frequent falls of a few feet over its rocky bed. After flowing through the Iron Mountains in a rocky gorge and entering Tennessee the Watauga is joined by Roan and Elk creeks, which have drainage areas with the same characteristics as its own. After the junction of these three streams the river flows through Carter and Washington counties, receiving tributaries on either side, the chief of which are Doe River, Buffalo Creek, and Stony Creek. About 20 miles southwest of Bristol the Watauga joins the South Fork of the Holston, and farther down, near Kingsport, the two forks of the Holston unite, forming one of the chief rivers of the State of Tennessee. Near Knoxville the Holston is joined by Nolichucky River, a stream but little smaller than itself, which derives its headwaters a few miles south of the source of the Watauga.

The Nolichucky is formed by the junction of the North Toe, the South Toe, and Caney River, all of which rise in the high mountains of Mitchell and Yancey counties, on the western border of North Carolina. The headwaters of the North Toe are separated from those of Elk Creek, of the Watauga drainage, by a narrow ridge. The North Toe flows to the southwest until its junction with the South Toe, which rises in the Black Mountains, after which it flows in a westerly direction and is joined by Caney River, which also rises in the Black Mountains but flows through a comparatively flat and open valley, draining a large part of Yancey County. After the junction with Caney River the stream is known as the Nolichucky, and flows to the west for 200 miles through the State of Tennessee, receiving numerous tributaries, the chief of which are Lick Creek and French Broad and Pigeon rivers.

The French Broad rises in the Blue Ridge, at the State line between North Carolina and South Carolina, flows in a northwesterly direction, at first with considerable fall, then enters the broad plateau, and with sluggish, even flow continues its course westward until it breaks through the Bald Mountains. Numerous tributaries are received on either side, all of which in their lower courses have the

characteristics of rivers of the plains. The fall of the French Broad from Brevard to Asheville, a distance of 50 miles, is 2.7 feet per mile.

On the north side of Grandfather Mountain are the headwaters of the South Fork of New River. This is the only stream in this region that flows northward. It drains about half of Watauga and Ashe counties, and flows through narrow valleys with steep mountain slopes on either side. After passing into Virginia it is joined by the North Fork of New River, and flows for 100 miles through that State, finally entering West Virginia, where it empties into the Great Kanawha, adding its waters to the Ohio.

From the southern slopes of Grandfather Mountain and the ridge between the towns of Grandfather and Blowing Rock flow the headwaters of the Yadkin.— For the first few miles the stream is small and the fall very great, being through a rough and wooded country; but soon the river reaches the vast plateau known as the Piedmont Plain, and its valley opens out into a broad and fertile area, with numerous branches on either side, those from the south, which rise in the Brushy Mountains, being small, while those from the north, which rise in the Blue Ridge, are streams with large flow and considerable fall. The many tributaries add large volumes of water to the Yadkin, and as it flows to the east its discharge increases rapidly, until by the time the South Carolina boundary line is reached it has become one of the largest rivers of the Southeastern States. It flows for 130 miles through the State of South Carolina under the name of Pedee River.

The many springs on the southern slope of Grandfather Mountain join to form John River and Mulberry and Wilson creeks, which unite about 20 miles to the south and finally add their waters to Catawba River. The Catawba rises in the Black Mountains and flows east, descending from the high mountain sides to the level of the Piedmont Plain in frequent leaps of from 5 to 10 feet, and in one or two cases with vertical falls of 100 feet. From Oldfort, in McDowell County, it flows through the heart of the Piedmont Plain, receiving large tributaries from the north, notably North Fork, Linville River, Upper Creek, John River, and Lower Creek, all of which rise on the eastern slopes of the Blue Ridge, two of the chief tributaries, Linville and John, receiving their headwaters from the springs on the slopes of Grandfather Mountain. The river flows to the east, entering Alexander County, where it turns to the south and crosses the South Carolina boundary, after which it is known as the Wateree.

There are two rivers in this region which differ somewhat in their general characteristics from the streams described, viz, the Broad and the Saluda. Broad River is formed by the junction of the main Broad, the Green, the First Broad, and the Second Broad, and receives its headwaters from the slopes of South Mountain and the Blue Ridge. The tributaries, however, soon reach the flat, open plain, and uniting near the State line enter South Carolina near the western border of York County. Farther to the southwest Saluda River receives the

run-off from the Blue Ridge and flows for almost its entire length through South Carolina. Tugaloo River, which flows into the Savannah; Oconee River, one of the chief streams of Georgia and a tributary of the Altamaha; and the Chattahoochee, which waters in part the States of Georgia, Alabama, and Florida, also rise in the Blue Ridge.

SCENERY.

The scenery of the Southern Appalachian region is the grandest in the Eastern States. While in height the mountains can hardly be compared with the Rockies or the Alps, they far outstrip in height, massiveness, and extent the mountains of the Northeastern States. As one ascends Roan Mountain or Grandfather Mountain or passes through Hickory Nut Gap he is strongly reminded of the scenery of Switzerland, and might well imagine that he was on the Rigi or the Pilatus.

The mountains and valleys are covered with a luxuriant growth of forest trees, making one continuous bank of green from the bases to the summits of the highest peaks. (See Pl. IV.) With tireless energy the rivers have cut their ways through the massive ranges and formed stupendous gorges with bare, rocky walls almost vertical and hundreds of feet in height. These gorges, which confine the wandering streams, present views of rare grandeur and wonderful beauty. The charms of the Linville (see Pl. XXXVIII, Part II), the Cranberry, and the Watauga can not fail to arouse the wonder and admiration of all who visit them. Among the mountains and adjoining elevated plateaus there are a number of places where people seek rest and recreation during the hot months of the year. The visitors, however, are largely from the Southern States, and after spending a summer in these mountains the writer can but marvel that they have been so long overlooked by the people of the Eastern States as an ideal place to enjoy beautiful scenery and exhilarating mountain air. It can be accounted for only by the fact that so little has been known regarding the region, and that it is, unfortunately, rather difficult of access, there being few railroads except those used for lumbering, and the highways being execrable. These drawbacks, however, are rapidly disappearing, and the region would well repay a visit from the tourist or the seeker for health.

In general the mountain views are made up of a billowy succession of ridges (shown in Pl. V), the deep green of the mountains melting into the blue of the sky in the distance, while nearer at hand more subdued shades of green prevail, which in the valleys below merge into the soft, ripe yellows of the grain fields, with here and there a bare cliff or an area of red soil which stands out in sharp contrast. From the Unakas and to the north and west, where lies the beautiful Valley of East Tennessee, the views are of a different character. There the inequalities of surface are almost lost, and for miles the eye rests on a great plain dotted with light-colored cultivated areas and with green forest masses. Among the Unakas many balds occur, of which



TYPICAL FOREST-COVERED MOUNTAIN SIDE.



RICHLAND VALLEY FROM JUNALESKA MOUNTAIN, NORTH CAROLINA.

Whitetop is one of the most conspicuous and those of the Roan the most extensive and beautiful, consisting, as they do, of three or four peaks extending along the top of the mountain in a chain about 6 miles long. Dr. Mitchell many years ago said of Roan Mountain: "It is the most beautiful, and will best repay the labor of ascending it, of all our high mountains. With the exception of a body of rocks looking like the ruins of an old castle, near its southwestern extremity, the top of the Roan may be described as a vast meadow without a tree to obstruct the prospect, where a person may gallop his horse for a mile or two, with Carolina at his feet on one side, and Tennessee at the other, and a green ocean of mountains rise in tremendous billows immediately around him." Some of the highest peaks, however, are not bald, but are covered with a dark and dense growth of balsam and other evergreens. It is from a somber vegetation of this kind that the Black Mountains derive their name.

From Mount Mitchell a view into six States can be had. Although that mountain is the highest peak east of the Rockies, the views from it are not so fine nor so extensive as can be obtained from other mountains of less elevation, for the reason that it is surrounded by peaks with altitudes little less than its own, while Roan Mountain and Grandfather Mountain tower far above their surroundings, and from them magnificent views can be obtained in all directions.

Grandfather Mountain (shown in Pls. VI and VII) is probably the most massive of the Southern Appalachians, and is the culmination of the Blue Ridge. The scenery from it is unsurpassed. For many miles range after range of mountains spread out like the waves of the ocean, with opalescent clouds hanging down in the valleys below. In spring and summer there is the glint of the sunshine on the moist green of the leaves. In autumn the somber green of the balsam and spruce crowning the summits rises above the scarlet and golden glories of the foliage of the hard-wood trees, while in winter the great peaks lie cold and white, bare and forbidding. At every turn some new and beautiful thing is offered. Below the peaks myriad little brawling crystal streams dash in fleecy white over the ledges and around the boulders that obstruct their courses (see Pl. VIII), or loiter in still pools where the rainbow trout lurk, while still lower are the green valleys hemmed in by the great mountains. On the slopes of Grandfather Mountain, from near the summit to the base, rise innumerable springs of pure, cold water, which uniting form rivulets that flow over rocky precipices and are finally joined into one of the several rivers which flow from its base. The mountain is covered with a heavy forest growth which has not yet known the woodman's ax. Nearly the whole of it, as well as its neighbor, Grandmother Mountain, is owned by the Linville Improvement Company, which controls 16,000 acres of the region, largely covered with forests, and, fortunately, lumbering is not their design. The company has laid out a town site in the valley of Linville River, at the foot of Grandfather Mountain, and intends to sell small tracts to

those who desire summer homes in the mountain region. In order that the springs which give rise to the streams on Grandfather Mountain may not be disturbed, 1,400 acres have been set aside as a public park, under five commissioners, one of whom is the State geologist and another the commissioner of agriculture of North Carolina.

The general contour of the mountains in the Southern Appalachian region is gentle, with smoothly rounded outlines (see Pl. IX), although occasionally sharp peaks are seen and here and there immense precipices are brought into view, especially in the southern portion of the region, as at Whiteside Mountain, one side of which presents a sheer face of naked rock 1,800 feet in height. (See Pl. X.)

CLIMATE.

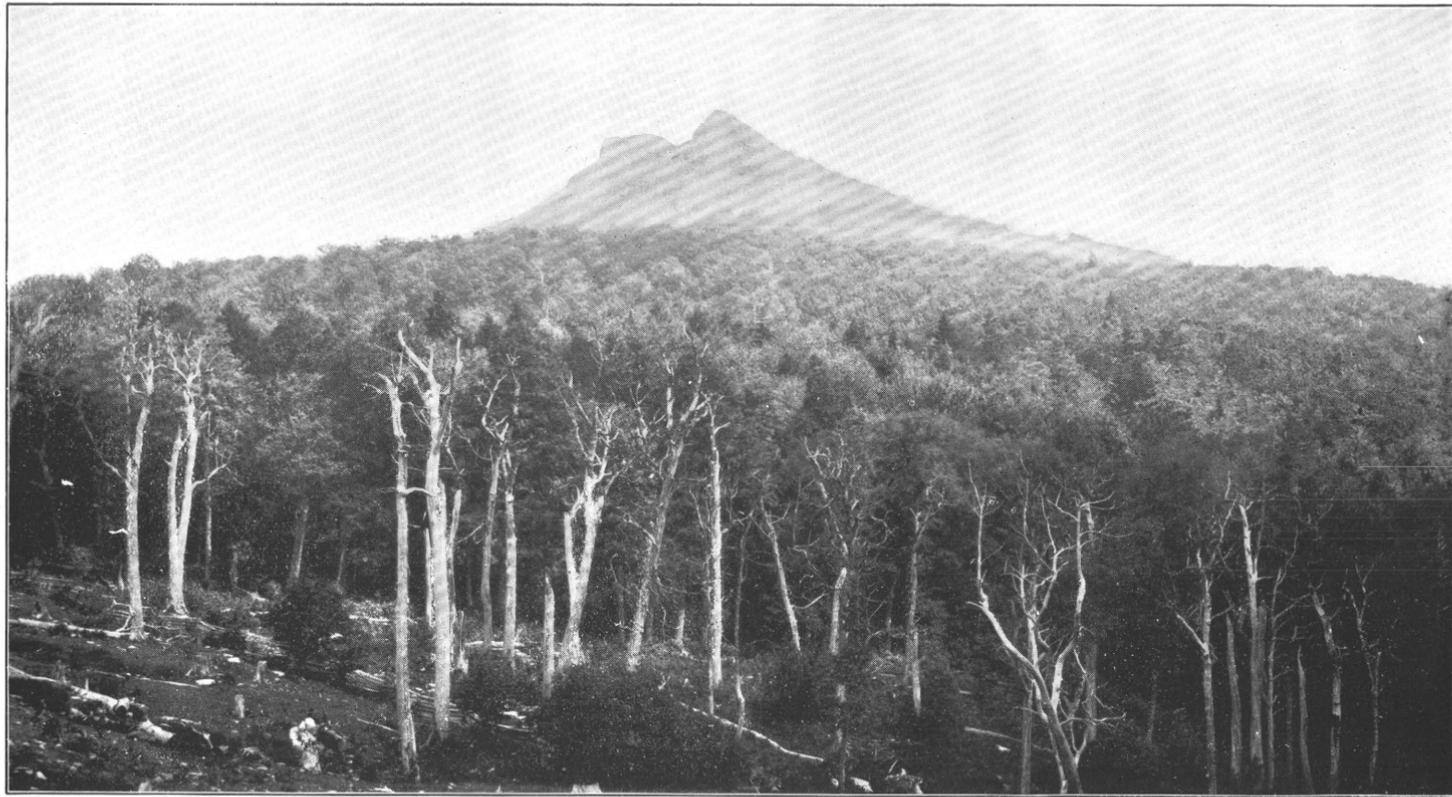
As has been stated, the Blue Ridge may be considered the great water divide. The mountain region lies to the north and west, while on the east is the Piedmont Plain. The effect of the increased altitude upon the climate is apparent. The high plateau may be said to have cooler summers and more severe winters than the lower lands adjacent, the air is drier and more salubrious, the summer months are remarkably pleasant, the temperature varying somewhat with the altitude, but never too cold for comfort on even the highest mountain peaks. By choosing the proper locality one can obtain an average temperature corresponding to that of northern New England or to the warmer temperatures of the South Atlantic States. The mean annual temperature varies from nearly 60° F. at Salisbury, east of the mountains, to 49° F. at Linville, the latter being about the mean annual temperature of Boston and Chicago. On the mountain slopes the mean annual temperature is still lower. The seasonal temperatures of the mountain region are approximately as follows: Spring, 56°; summer, 73°; autumn, 57°; and winter, 40°. The following table gives the average monthly temperature, the mean annual temperature, and the seasonal temperatures as observed at the Weather Bureau stations in the mountain region:

Temperature observations in Southern Appalachian Mountains during 1900.

Station.	Average monthly temperature.												Mean annual temperature.
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	
Biltmore.....	Deg. 36.1	Deg. 34.3	Deg. 44.9	Deg. 56.2	Deg. 63.9	Deg. 70.8	Deg. 74.6	Deg. 74.8	Deg. 69.9	Deg. 59.8	Deg. 47.5	Deg. 39.4	Deg. 56.0
Charlotte.....	41.4	39.5	48.1	59.6	69.0	74.8	79.4	81.9	76.4	65.2	52.0	42.6	60.8
Cherrette.....	41.0	39.5	50.0	60.0	68.3	74.6	79.9	81.5	76.0	64.8	52.4	43.1	60.9
Hendersonville..	36.6	34.6	45.1	54.4	62.4	70.2	73.4	75.4	70.4	62.6	50.0	40.5	56.3
Highlands.....	32.8	30.6	38.4	51.0	58.4	64.1	67.5	68.1	63.6	56.2	45.3	35.8	51.0
Horse Cove.....	38.4	35.5	43.6	56.0	62.8	66.6	71.6	74.4	69.4	60.4	49.6	40.6	55.7
Linville.....	30.3	29.0	36.8	48.0	55.6	64.5	67.2	67.6	63.1	54.3	43.6	34.0	49.5
Morgantown.....						73.8	79.0	80.0	74.0	62.1	50.9	41.4	
Mount Airy.....	37.0	35.6	42.6	55.8	62.4	70.0	76.6	77.6	71.7	61.9	48.7	38.8	56.6
Marion.....	38.8	36.2	46.8	57.8	66.6	72.8	78.2	80.1	75.2	63.3	51.2	41.5	59.0
Marshall.....	33.8	34.6	43.2	54.6	64.2	72.0	75.8	75.5	69.6	61.2			
Waynesville.....	35.2	36.1	43.6	52.6	61.0	68.5	71.8	71.4	67.2	58.4	44.0	37.5	53.9

* Record for three days missing.

b Record for six days missing.



GRANDFATHER MOUNTAIN, NORTH CAROLINA.



CENTER, GRANDFATHER MOUNTAIN, NORTH CAROLINA (HIGH PEAK IN BACKGROUND), FROM PIXIE.

Temperature observations in Southern Appalachian Mountains, etc.—Continued.

Station.	Seasonal temperatures.				Latitude.	Longitude.	Elevation.	Length of record.
	Spring.	Summer.	Autumn.	Winter.				
	Deg.	Deg.	Deg.	Deg.	° '	° '	Feet.	Years.
Biltmore	55.0	73.4	59.0	36.6				2
Charlotte	58.9	78.7	64.5	41.2	35 13	80 51	808	22
Henrietta	59.4	78.7	64.4	41.2				
Hendersonville	54.0	73.0	61.0	37.2				1
Highlands	49.3	66.6	55.9	33.1	35 5	83 25	3,817	15
Horse Cove	54.1	70.9	59.8	38.2	35 0	83 6	2,800	6
Linville	46.8	66.4	53.7	31.1	36 5	81 51	3,800	4
Morganton		77.6	62.3		35 45	81 44	1,135	9
Mount Airy	53.6	74.7	60.8	37.1	36 30	80 40	1,048	10
Marion	57.1	77.0	63.2	38.8	35 30	82 5	1,425	5
Marshall	54.0	74.8						
Waynesville	52.4	70.6	56.5	36.3	35 23	82 58	2,756	4

Highlands, the highest station, is 3,817 feet in elevation, while several of the mountain ranges and peaks reach altitudes of from 5,000 to 6,000 feet, and their temperatures are lower than those given in the table. The following table gives the temperature extremes at a number of observation stations:

Temperature extremes in Southern Appalachian region.

Station.	Elevations.	Length of record.	Highest monthly mean.		Lowest monthly mean.		Highest observed.		Lowest observed.	
			Temperature.	Date.	Temperature.	Date.	Temperature.	Date.	Temperature.	Date.
	Feet.	Yrs.	Deg.		Deg.		Deg.		Deg.	
Asheville	2,250	23	74.8	July, 1879	27.2	Jan., 1893	95	Sept. 15, 1897	-9	Jan. 16, 1893 Feb. 8, 1895
Chapel Hill	500	41	82.2	July, 1893	28.4	Jan., 1857	105	Aug. 10, 1892	-1	Jan. 16, 1893
Greensboro	843	15	82.6	do	32.3	Dec., 1876	101	Aug. 10, 1896	-6	Jan. 28, 1897
Highlands	3,817	15	70.9	July, 1878	24.4	Jan., 1893	86	June —, 1891	-17	Feb. 8, 1895
Horse Cove	2,800	6	74.4	July, 1893	28.5	do	93	Sept. 15, 1897	-13	Do.
Lenoir	1,186	26	77.7	July, 1877	27.3	do	95	July 18, 1887	-16	Dec. —, 1880
Morganton	1,048	10	80.0	July, 1868	26.4	do	100	Sept. 16, 1897	-1	Jan. 16, 1893
Mount Airy	1,048	10	77.1	July, 1872	26.2	do	98	Sept. 28, 1891	-15	Do.
Mount Pleasant	650	12	79.1	Aug., 1896	29.9	do	98	June 29, 1889	-4	Jan. 21, 1893
Murphy	1,614	12	76.9	July, 1878	28.5	Dec., 1876				
Salisbury	760	13	82.0	July, 1893	33.0	Jan., 1893	102	Aug. 10, 1896	5	Feb. 21, 1896

* Minus sign indicates temperature below zero.

PRECIPITATION.

The annual rainfall is copious, larger than anywhere else in the United States except on the northwestern coast, in Oregon and Washington. As might be supposed, it varies considerably in different parts of the high regions. The warm, moist winds from the east and south are deflected upward by the Blue Ridge, causing a cooling and consequent precipitation. In this way the yearly rainfall is greatly increased on the slopes of those mountains. At Highlands, in Macon County, the annual normal precipitation is about 72 inches and at Horse Cove about 73 inches. West of the Blue Ridge the annual rain-

fall is much less in the valley bottoms between the mountain ranges. For instance, a long record at Asheville gives a normal rainfall of about 42 inches, the smallest of any record of the mountain region. The normal at Waynesville, in Haywood County, is 46 inches. The average precipitation of the whole region may be considered to be approximately 53 inches. The following table gives the monthly, annual, and seasonal precipitation for 1900:

Precipitation in Southern Appalachian region during 1900.

Station.	Monthly precipitation.												Mean annual.
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	
	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>	
Abshers.....	3.35	7.50	4.92	4.89	2.93	9.28	7.43	4.14	5.46	8.73	5.15	3.35	67.13
Asheville.....	2.28	4.67	5.53	4.18	0.99	8.11	1.99	2.54	3.39	2.92	4.62	3.46	44.66
Biltmore.....	2.41	6.90	2.87	3.31	1.37	7.91	2.10	0.52	2.51	3.67	3.34	3.40	40.71
Bryson.....	2.85	7.72	7.33	4.67	1.21	6.31	2.88	4.48	3.02	2.87	4.80	4.76	52.90
Charlotte.....	2.15	5.25	5.28	5.32	2.11	7.31	3.55	3.05	0.73	3.41	3.85	4.33	46.34
Cherryville.....	3.31	7.01	5.65	7.55	3.34	6.39	2.25	2.61	2.01	2.29	4.04	4.80	51.25
Flatrock.....	.....	13.24	5.06	.....	.....	.....	.....	.....	.....	8.17	3.87	3.90	.....
Hendersonville.....	3.94	10.10	5.76	8.06	3.83	8.79	5.75	1.53	3.80	4.10	3.47	4.98	64.11
Henrietta.....	3.09	10.69	5.29	6.77	2.92	6.99	2.79	1.45	1.05	4.15	5.27	5.10	55.56
Highlands.....	5.82	13.84	7.10	10.20	1.67	19.29	8.04	1.95	4.99	6.00	5.03	7.53	91.46
Horse Cove.....	4.28	12.98	7.10	8.83	2.28	19.92	9.43	3.36	6.74	8.63	5.94	6.67	96.16
Linville.....	2.63	5.34	7.60	5.51	2.17	7.07	3.99	3.70	4.42	13.40	4.47	3.95	64.25
Maria.....	.....	2.13	5.17	4.06	.....	.....	.....	.....	.....	.....	.....	.....	.....
Marion.....	3.59	9.22	6.65	9.70	1.96	10.56	3.52	2.70	3.48	9.69	4.04	4.74	69.79
Marshall.....	1.26	4.07	3.69	2.62	1.43	8.33	1.49	2.69	3.63	3.51	2.25	3.09	38.09
Mount Airy.....	2.35	4.00	3.50	3.67	1.02	8.56	3.52	2.50	4.12	4.04	3.10	3.38	43.76
Mount Pleasant.....	2.11	6.68	3.07	4.34	2.53	4.87	.....	.....	.....	.....	.....	.....	.....
Morganton.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mocksville.....	3.40	4.38	6.18	4.68	3.13	3.45	2.65	1.15	2.10	3.26	2.26	4.40	.....
Murphy.....	3.55	6.45	5.07	4.83	2.19	8.87	4.04	2.78	3.19	5.19	5.22	5.45	58.83
Salisbury.....	3.22	4.52	5.02	4.98	4.12	4.81	3.52	1.79	1.60	1.90	2.10	6.25	43.93
Settle.....	2.82	5.34	3.30	4.30	2.40	5.57	2.43	3.95	3.56	2.99	3.08	4.51	44.25
Waynesville.....	2.38	6.97	6.00	6.41	1.01	7.64	3.55	2.25	2.49	2.12	3.57	4.08	48.47

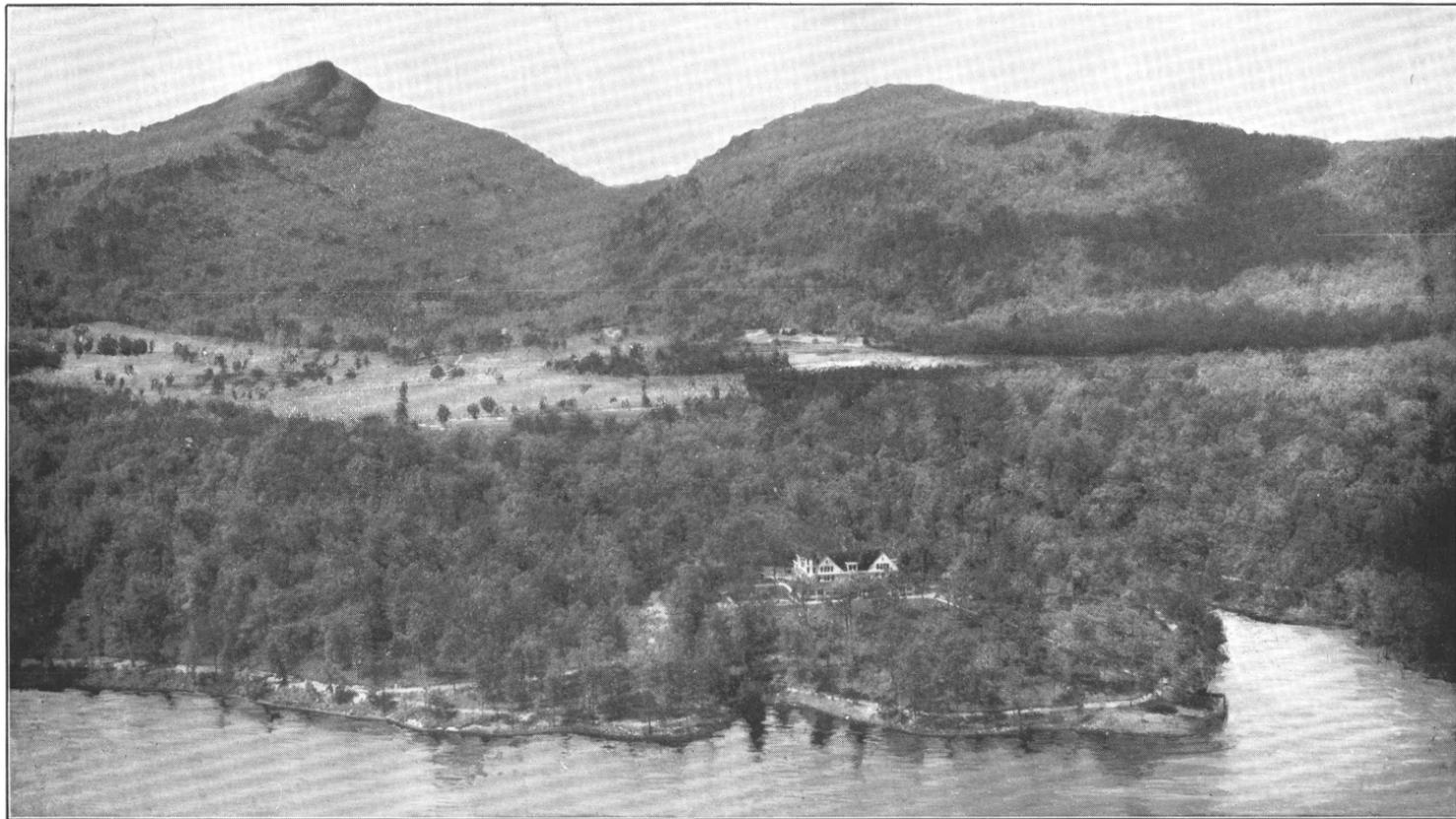
Station.	Seasonal precipitation.				Latitude.	Longitude.	Elevation.	Length of record.
	Spring.	Summer.	Autumn.	Winter.				
	<i>In.</i>	<i>In.</i>	<i>In.</i>	<i>In.</i>				
Abshers.....	12.74	20.85	19.34	14.20	.....	.....	.....	.....
Asheville.....	10.70	12.64	10.93	10.39	35 37	82 30	2,250	22
Biltmore.....	7.55	10.53	9.52	13.11	.....	.....	2,150	2
Bryson.....	13.21	13.67	10.69	15.33	35 27	83 23	2,000	10
Charlotte.....	12.71	13.91	7.99	11.73	35 13	80 51	898	22
Cherryville.....	16.54	11.25	8.34	15.12	.....	.....	.....	.....
Flatrock.....	.....	.....	.....	.....	35 15	82 25	2,214	6
Hendersonville.....	17.65	16.07	11.37	19.02	.....	.....	2,167	1
Henrietta.....	14.98	11.23	10.47	18.88	.....	.....	.....	.....
Highlands.....	18.97	29.28	16.02	27.19	35 5	83 25	3,817	15
Horse Cove.....	18.21	32.71	21.31	23.93	35 0	83 6	2,800	6
Linville.....	15.28	14.76	22.29	11.92	36 5	81 51	3,800	4
Maria.....	.....	.....	.....	.....	.....	.....	.....	.....
Marion.....	18.31	16.72	17.21	17.55	.....	.....	1,425	5
Marshall.....	7.77	12.51	9.39	8.42	.....	.....	.....	.....
Mount Airy.....	8.19	14.58	11.26	9.73	36 30	80 40	1,048	10
Mount Pleasant.....	9.94	.....	.....	.....	35 28	80 28	650	12
Morganton.....	.....	9.77	7.56	.....	.....	.....	1,135	9
Mocksville.....	13.99	.....	8.43	11.10	35 51	80 34	651	4
Murphy.....	14.09	15.69	13.60	15.45	35 8	84 0	1,614	20
Salisbury.....	14.12	10.12	5.60	14.09	35 4	80 29	760	13
Settle.....	10.00	11.95	9.63	12.67	.....	.....	.....	2
Waynesville.....	13.42	13.44	8.18	13.43	35 29	82 58	2,756	4

*Partly estimated.

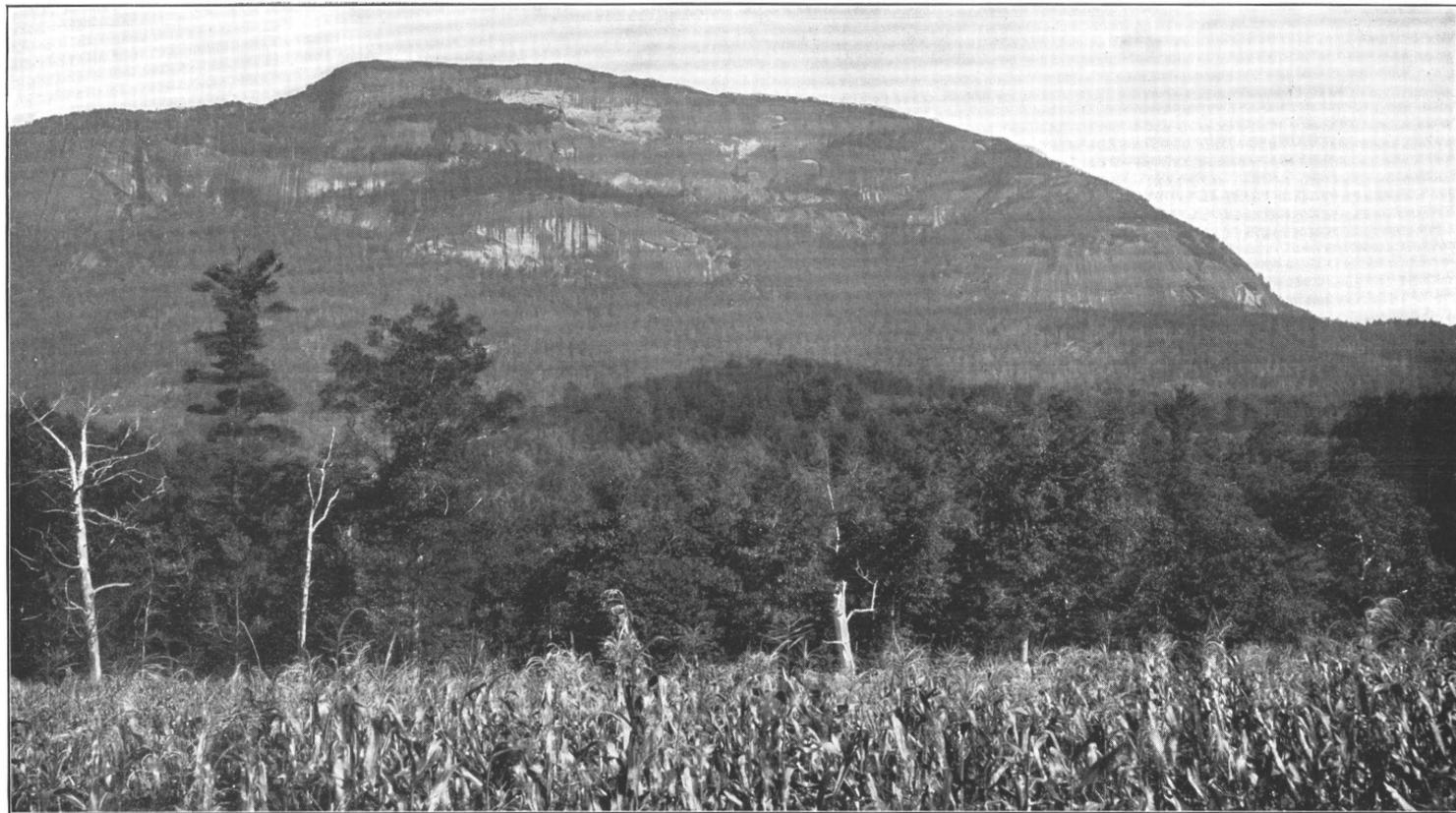
Heavy rains occur at short intervals, which with the steep slopes cause rapid increase in the flow of the streams for a day or a few



SKYUKA FALLS, NORTH CAROLINA, A TYPICAL MOUNTAIN WATERFALL.



VIEW IN THE SAPPHIRE COUNTRY, NORTH CAROLINA, SHOWING SMOOTHLY-ROUNDED TOPOGRAPHY.



WHITESIDE MOUNTAIN, NORTH CAROLINA.

hours, when the rivers as rapidly fall to their normal stage. Floods are frequently caused by the heavy rains. It is exceedingly difficult, however, to obtain measurements of the extreme high waters, for unless one is near the station at the time the water rises the river falls before he can reach there. A rainfall of 7.39 inches was recorded at Salisbury on June 10, 1883, and 6.01 inches at Highlands on February 8 and 9, 1891.

There is considerable snowfall during the winter months of the year, the average annual snowfall at a few stations being as follows: Asheville, 16 inches; Highlands, 22 inches; Lenoir, 11 inches; and Mount Airy, 12 inches.

The following table gives the greatest and least monthly precipitation:

Table showing greatest and least monthly precipitation in Southern Appalachian region.

Station.	Elevation.	Length of record.	Greatest monthly precipitation.		Least monthly precipitation.		Highest monthly average.	Lowest monthly average.
			Amount.	Date.	Amount.	Date.		
	<i>Feet.</i>	<i>Years.</i>	<i>Inches.</i>		<i>Inches.</i>		<i>Per cent.</i>	<i>Per cent.</i>
Asheville.....	2,250	23	*11.40	July, 1874	0.21	Oct., 1895	143	74
Charlotte.....	808	22	11.13	Mar., 1891	0.23	Nov., 1890	126	74
Highlands.....	3,817	15	20.20	Feb., 1891	0.25	May, 1883	135	79
Horse Cove.....	2,800	6	17.02	June, 1892	0.62	Oct., 1892	136	38
Lenoir.....	1,186	23	11.50	May, 1873	0.00	Nov., 1890	133	78
Morganton.....	1,135	10	11.20	Apr., 1878	0.20	Oct., 1892	129	67
Mount Airy.....	1,048	10	10.38	July, 1889	0.17	Nov., 1890	147	60
Mount Pleasant.....	650	12	10.27	Aug., 1887	0.28	Oct., 1892	142	66
Salisbury.....	760	13	16.14	.....do.....	0.13	Nov., 1890	128	67

FORESTS AND LUMBERING.^b

Nearly the whole of these mountains was once covered with a magnificent growth of timber, which owing to its inaccessibility was long spared the woodman's ax. Now, however, since the forests of the North and the West have been denuded, the lumbering element has turned its attention to the Southern Appalachians, and the vast forests there are rapidly disappearing. Railroads have penetrated the mountains, and mills large and small have been located in the forested areas. One great railroad traverses the heart of the region, with a branch from Asheville through Macon and Cherokee counties. Lines have also been constructed up Doe and Nolichucky rivers, and a number of other lines have been surveyed, some of which will probably be built within a few years. Wherever a railroad is constructed the neighboring timber soon disappears, in consequence of the cheaper transportation. Most of the large mills are steam sawmills, and they are moved deeper into the forests as the supply of timber in their immediate vicinity is exhausted, the railroads being extended to them. Near the rivers the logs are splashed down the streams to the timber

^a There is record of a greater amount than this, but it is not considered quite trustworthy.

^b During the summer and fall of 1900 extensive investigations of the forests of the Southern Appalachian region were made by the United States Bureau of Forestry, Gifford Pinchot, forester.

pens of the mills below, thus saving the cost of railroad transportation or long hauls over rough and steep roads. Splash dams are constructed which hold back the water in dry seasons and float the logs over the rocky beds of the streams.

Notwithstanding the inroads that have been made on these forests, nowhere in the United States is there an equal area of land covered with so great a variety of valuable timber. The walnuts, tulips (poplars), and oaks grow to almost incredible size (see Pl. XI). In many localities white pine occurs in large tracts, growing to great heights (see Pl. XII) and furnishing as fine lumber as any of the pine forests of the country. Near the summits of all of the higher mountains the only growth is the balsam. Most of these trees are exposed to the cold and wind, and for that reason are small and twisted (see Pl. XIII, A), but where protected they grow to large size, especially in the Craggy and the Smoky mountains. Numerous varieties of rhododendrons grow on the slopes of many of the mountains, forming an almost impenetrable jungle. During the flowering season these present a most beautiful appearance, being often a mass of blossoms stretching as far as the eye can reach in every direction. Grandfather Mountain is particularly rich in this growth (see Pl. XIII, B), the chief species being *Rhododendron maximum*, *Rhododendron catawbiense*, and *Rhododendron vaseyi*.

Although the region still has the finest hard-wood forests in the country, the large tracts of wild cherry and black walnut which once flourished have entirely disappeared, and the mills are now sawing cheaper lumbers, such as oak, white pine, ash, and poplar. Not many years ago the supply of walnut was so abundant that old mountaineers tell of splitting rails from walnut logs and of burning or allowing to rot the walnut stumps which to-day would bring immense sums from veneering factories. The unfortunate feature of this lumbering is that there is no discrimination in the cutting. All of the trees, large and small, are felled, and if found not suitable for immediate use they are allowed to rot on the ground. In many places the lumber companies are recutting areas which have once been gone over, and are denuding them of even the smallest trees. Some of the companies saw anything that will make a plank. In the case of the bark gatherers the wastefulness is particularly deplorable. These men fell the trees—chiefly chestnut-oak and hemlock—for the bark, and after stripping them make no attempt to use the timber. Every year hundreds of cords of bark are hauled from these mountains, and each load means that some giant of the forest lies useless on its native soil. Near the railroads it is profitable to saw the timber and haul it to the station, but the natives find that they can strip the trees and haul the bark much farther than they can afford to haul the timber. It is a mournful sight to see these immense trees lying where felled, of no use to anybody, simply marking the wanton wastefulness of man.



POPLAR FOREST.



PINE FOREST.



A. WIND-DWARFED BALSAM FIR ON GRANDFATHER MOUNTAIN, NORTH CAROLINA.



B. RHODODENDRON THICKET, NEAR GRANDFATHER MOUNTAIN.

Lumbering on a large scale has been carried on for only a few years, but in addition to the large steam mills, which are moved deeper into the forest as the timber in their vicinity is exhausted, every little creek now has one or two small water-power sawmills cutting from 500 to 5,000 feet a day. Dry kilns are built and planers are put in so that the mills can turn out finished lumber. Although by the old methods fearful inroads were made on the forests, so thorough is the denudation by the new mills that it will not take them many years to exhaust all of the timber that is worth sawing.

The four largest lumber plants operating in this section are the Watauga Lumber Company, on Watauga River; the Empire Company, in the Shady Valley; the Ritter Company, at Pineola, on Linville River; and a new company with main yards at Huntsdale, Tenn., on the Nolichucky.

The Watauga Lumber Company owns almost all of the timber in the Watauga Valley. They have built five splash dams for the purpose of floating logs down to their mill. Two of these dams are on the main river, one at Shulls Mill and the other just above the mouth of Beaverdam Creek. On Beaverdam Creek there is a splash dam about 2 miles from the mouth, and during the summer of 1900 the company removed much of the timber from the lower part of the Beaverdam Valley. About 6 miles up Laurel Creek they have another splash dam, and are now cutting the timber in that region. The fifth dam is on Elk Creek, just below the big falls. They have not commenced lumbering there yet, but they own all of the timber. At Shulls Mill the company has built a tramroad up in the mountains to haul their logs to the river. They cut only the white pine and the poplar, because of the distance the logs have to be splashed. They now have thousands of logs all along the river from Shulls Mill to their mill below Elizabethton.

The Empire Company started work in the Shady Valley during the summer of 1900. They have put up a large mill and timber pen on Beaverdam Creek, and later will put in a dry kiln. The mill is to be run by steam. The Holston Valley Railroad is being built from Abingdon, Va., for the purpose of getting this lumber out. The railroad follows down the South Fork of Holston River to the mouth of the Laurel Fork, then up the Laurel Fork and Beaverdam Creek. This is considered one of the finest timber regions in the mountain section, consisting mostly of white pine and spruce, with a very little hard wood, mostly chestnut. The land being very fertile, the trees have grown to great size, being nearly 100 feet to the first limb. Up to the present time the timber in this valley has been almost untouched, on account of the long haul over the mountains to a railroad.

The Ritter Company, at Pineola, has had its mill in operation about a year. It is run by steam, and has a capacity of 50,000 feet a day. Their timber pen is on Linville River, and the logs are brought to it

by a narrow-gage railroad, which also carries the timber to Johnson City, Tenn., by way of Cranberry, N. C. The tract of this company, which contains some very fine white pine, extends from Pineola to Linville Falls, on both sides of Linville River, and includes most of the timber on Jonas Ridge.

The Ohio River and Charleston Railroad has been constructed from Johnson City, Tenn., up the valley of Nolichucky River as far as the mouth of Caney River, and a large lumber yard and shipping point have been established at Huntsdale, Tenn. A number of steam saw-mills have also been built on the slopes of the Black Mountains. These mills are temporary structures and will be moved from point to point to avoid long hauls of the logs. The lumber is hauled to Huntsdale for shipment. Huntsdale has sprung up on the banks of the Nolichucky like a western mining town, and is not yet on maps of the region. The owners expect to extend the railroad very soon. It is said that they have bought 1,000,000 trees and are still increasing their purchases.

Several other companies are doing considerable lumbering. A company in Bristol has built a railroad to transport timber from the mountains south of Bristol across the South Fork of Holston River.

The many wood-working establishments on the Tennessee side of the mountains use considerable lumber, and close to the railroad on that side much soft wood is cut for the pulp mills in Bristol and other places.

Despite the great inroads on the forests in this region, many large areas have not been touched. The timber near the tops of all of the higher and steeper ridges still remains. This is particularly noticeable in the area between the South Fork of Holston River and the Watauga, where, except in the Shady Valley, which is now being cleared, all the timber that could easily be reached is gone, and only that at the tops of the steepest mountains remains. Three especially large areas, however, have not been cut, namely, Grandfather Mountain, the Black Mountains, and the long strip of land on both sides of Linville River. Grandfather Mountain is owned by the Linville Improvement Company, and it is not likely that they will permit any lumbering. The variety of trees in this area is greater than in the other regions, being hard woods near the base of the mountain and fir near the summit. The Black Mountains have escaped the lumberman only because of the difficulty of removing the logs and getting the lumber to market. Since the completion of the Ohio River and Charlestown Railroad to Huntsdale, however, several mills have started work around the bases of those mountains, and it will not be long before the timber is cut well up the sides.

On both sides of Linville River, from just below Linville to Beech Bottom, there is a very large strip of land containing exceptionally fine timber which has not been cleared of even the most valuable

trees. The upper end of this strip, however, is owned by the Ritter Company, and they are clearing the area, as already mentioned. Their tract extends from just below Linville nearly to Linville Falls, and contains some especially fine white pine. The next strip, extending from a half mile above the falls to $3\frac{1}{2}$ miles below them on each side of the river, and containing 51,000 acres, is owned by the Morganton Improvement Company. The next lower area, running down the river to Beech Bottom, belongs to the Cheever Improvement Company. The two latter tracts are very rich in white pine, poplar, ash, oak, hemlock, spruce, and the linn or linden.

Three railroads have been surveyed to run through this district—one from Bristol to Lincolnton, another from Cooks Gap to Lenoir, and the third from Collettsville, on John River, to Cranberry, to connect with the narrow-gage railroad running to Johnson City, Tenn. If these railroads are built the timber in the vicinity will soon be cut, leaving the ground bare, as it is along the other roads.

The unfortunate feature of the lumbering is that the ground is completely stripped of trees and then is left without cultivation. The slopes are often too steep for successful farming, and in many places the top soil is washed off and the hillsides become more or less gullied by the water rushing down the mountains.

Great as has been the havoc wrought by the lumberman, his part in the forest destruction has been small when compared with that of the clearing of the land for agricultural purposes and with forest fires. Too often the farmer, instead of trying to improve the soil in the valley, makes additional clearings on the mountain sides. Owing to the steepness of the slopes, the productiveness of the hillside fields is short lived. After the trees have been girdled and the underbrush destroyed the land can be planted in corn for one or two years, then in grain for a year, and then in grass for one or two years, after which it can be used as pasture land for a year or two, until, with increasing barrenness, the grass gives place to weeds and the weeds in turn to gullies.

Forest fires have been one of the great curses in the Southern Appalachians, as elsewhere in the country. They were of frequent occurrence in the days of Indian occupation. Thus they have preceded the lumberman, have accompanied him, and have followed in his wake, and their work has been rendered far more destructive by the lumberman leaving brush scattered among the remaining growth in such a way that in the burning it has fed the fires.

In some regions fires have entirely destroyed the forests, especially where the soil was thin and composed largely of humus. The burning of the humus has resulted in the remaining soil being soon washed away, leaving the trees standing on the bare surface of rock to dry out and die. In other places fires have destroyed the undergrowth and the larger trees have been burned near the roots in such a way

as to cause their destruction. Repeated fires in the undergrowth have exterminated the grasses and other forage plants over large areas, so that instead of improving the pasturage, which is frequently the object of starting the fires, the result has been in the course of years its almost total destruction.

That the burning of the humus and undergrowth in the forests seriously affects the flow of the streams anyone who has been in a forest during a heavy rain storm will admit. In the virgin forest the rain-drops are caught by the underbrush and pass downward through the humus into the less porous soil and the rock fissures beneath, to reappear weeks and months later in the form of numberless springs. But where the underbrush and humus have been burned away much less water soaks into the soil, most of it flowing down the surface with a velocity varying with the slope, washing the soil into small furrows and gullies, causing the rapid accumulation of the water into brooks, and resulting in floods in the larger streams in the valleys below.

In New England and many of the Northern States the numerous lakes and glacial deposits of sand and gravel spread out over the hills and valleys of that region serve as a storehouse for the water and materially assist the forest cover in preserving uniformity in the flow of the streams. Indeed, they would accomplish much in that direction were the forest cover entirely removed. But in the Southern Appalachian region there are no lakes and no glacial gravels and sands, hence the water storage depends entirely upon the forests and the soil.

SOIL AND VEGETATION.

Besides the actual reduction of the earth's surface according as the rocks differ in susceptibility to atmospheric agencies, the region has been profoundly affected by the soils which the rocks have produced, for on the soils the character and amount of the vegetation are largely dependent.

The soil is naturally deep and fairly fertile even to the mountain tops, while the valleys, which have been cleared, are remarkable for their fertility. In the valley of each little mountain stream can be seen the small cabins of the mountaineers, who cultivate the narrow tracts of land close to the river and often attempt agriculture on the steep slopes of the mountain sides. Pl. XIV gives views of two characteristic mountain homes. In these houses the natives live on from generation to generation, seemingly without desire for change or betterment. When the eldest son is married he is given a portion of his father's land, which he in turn attempts to clear and cultivate, managing to eke out a scanty existence, and being, like his forefathers, well satisfied with his surroundings and his condition in life. Fruits and vegetables grow abundantly and to large size, and would no doubt be cultivated much more were it not for the lack of means of transportation. The entire region is well adapted to stock raising, which is



A.



B.

TYPICAL MOUNTAIN HOMES.



SPRING ON BLACK MOUNTAINS, SHOWING DENSE PLANT GROWTH.

one of the chief industries. Years ago General Clingman wrote: "Horses and horned cattle are usually driven out into the mountains about the first of April and brought back in November. Within six weeks after they have thus been put into the range they become fat and sleek. There are, however, on the top and along the sides of the higher mountains evergreen and winter grasses on which horses and horned cattle live well through the entire winter. Such animals are often foaled and reared there until fit for market, without even seeing a cultivated plantation." This custom of turning the stock loose on the mountains still continues; and in recent years considerable attention has been given to fine stock breeding.

Many varieties of shrubs and flowering plants abound, and the region should prove a Mecca for botanists. Pl. XV (a view on the Black Mountains) will give an idea of the great variety of ferns and plants with which the mountain slopes are covered. In the foreground is one of the cool springs for which the region is noted.

According to Mr. Arthur Keith, of the U. S. Geological Survey, "the moist atmosphere is conducive to the rapid decay of the rocks, which break up chiefly under the attack of rain, frost, the roots of the trees, the underground waters, and organic acids. At first decay works in along the various partings, resulting in the loosening of large masses, which gradually become smaller, until finally nothing is left of them except clay and the more obdurate bits of rock. The rocks reach the surface over only very small patches, while in places the disintegration attains a depth as great as 50 feet. On sloping surfaces the loose material is maintained in its place solely by friction. When this is lessened or overcome from any cause, the residual matter, be it clay or rock fragments, slides down the slope until the friction is again sufficient to retain it in one position. Thus are formed immense deposits washed down from steep slopes and accumulated in the hollows and flatter places. This material gradually works its way downhill, as it is pushed along by the freezing of the water, or is rendered more unstable as the water transforms it into mud. Eventually it finds its way into the streams and is carried by slow stages into the sea.

"The chief agent which checks this process of removal is the forest cover, even though the penetrating roots and the acids due to vegetation induce rock decomposition. These same roots, however, hold the loose material in place and check its tendency to slide downhill. With this assistance loose soils are upheld on slopes fully double those which they could maintain unaided. Besides this direct hindrance to the waste of slopes by increased friction, the action of the forests is as great in another way. Loose material is washed downhill during rain storms by even the tiniest rivulets.^a In open fields these gather in a

^aPl. XVI, A, shows the starting of such a wash in a deforested area and illustrates the way in which this wash is checked by the growth of trees higher on the mountain side. H. A. P.

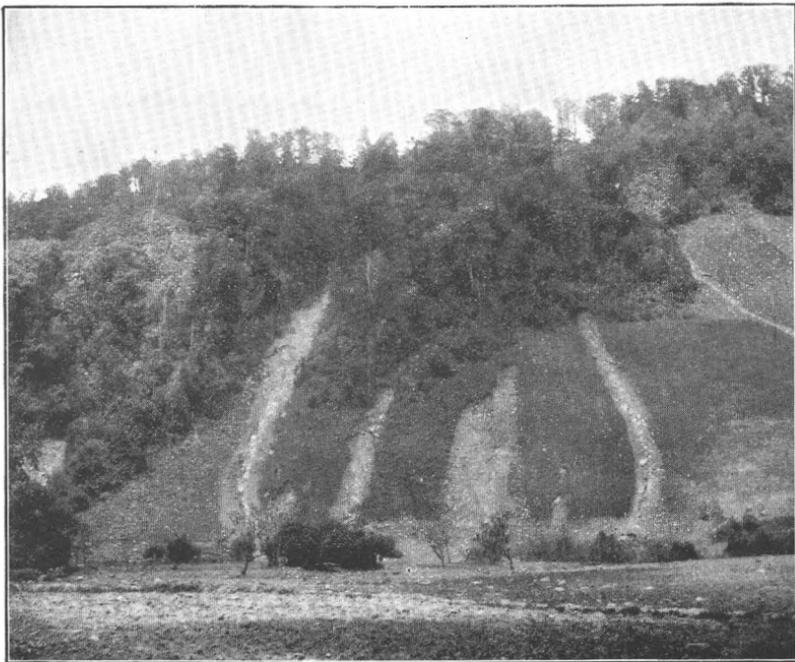
few minutes, and form deeper and deeper channels with each succeeding storm, finally removing the loose material down to the bare rock. This process is almost prohibited by the network of roots and the cover of leaves, both living and dead, and the water concentrates into rivulets by seeping through the soils so slowly that it carries no sediment. The waters finally drain off in the hollows and small streams whose channels have been fitted by long use to withstand the attacks of rushing water.

“Countless illustrations of this process can be seen during any rain storm. Streams which drain considerable areas of cleared land rise fast and become turbid with mud. Those which drain areas protected by forests rise much more slowly, and by comparison the water could be called clear, except in violent storms. This result is of course most striking at the very headwaters, the little streams rising in the fields and in the woods. The effects of this work are seen in the innumerable gullies which gash fields left to the elements for any time. In fact, unless checked by the most constant attention these gullies soon strip off the soil and clay and ruin the fields.^a In the forests, on the other hand, one rarely sees a slope of soil not covered with vegetation, and it is only along the immediate banks of the streams that raw slopes of loose material are exposed. In short, in this region of deep residual soils the influence of the forest is paramount. It is a fact well known among the mountaineers that the soils are far more fertile when first cleared from timber than ever again. It is equally well known among the farmers along the river bottoms that the same crops have been planted there with equal success for scores of years. These latter soils, however, are refreshed from time to time by the overflowing waters, which have swept off fertile materials from the steeper slopes above. The natural fertility of the mountain soils is very great, as is abundantly shown by the dense and luxuriant forest growth. The pristine strength of the soil soon wanes in the clearings, however, and there ensues a loss which is permanent for at least a generation. To convince one’s self of the existence of this condition it is only necessary to visit the region.

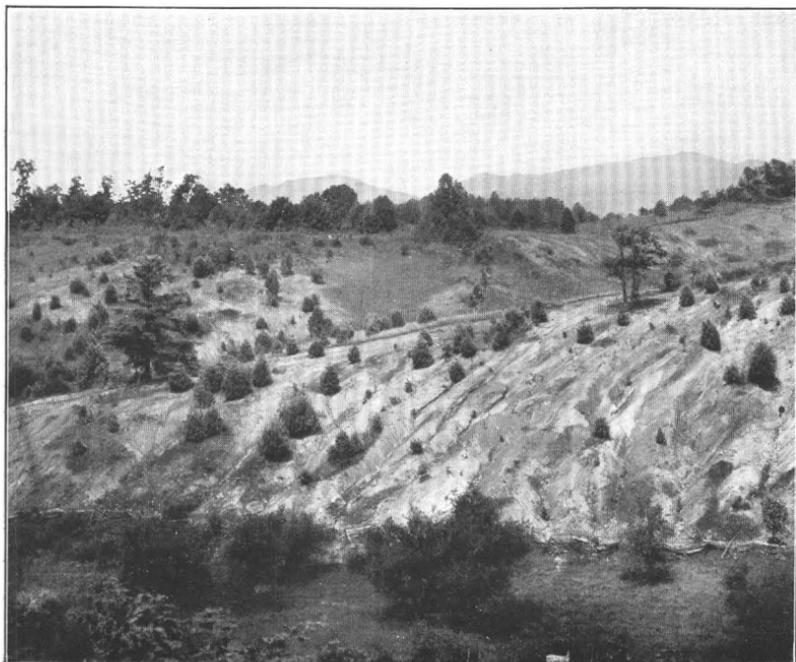
“In addition to the loss inflicted by forest cutting upon the steep slopes themselves great damage also results to the lands lying farther down the streams. The deep clays and underlying rocks form a kind of gigantic sponge which stores up water during its plenty. When the forests are stripped away the waters collect and run off with vastly greater speed, and much evaporates, so that not only is less stored up, but the discharge is more irregular and temporary. Destructive floods result and droughts are wider spread. Thus, viewed from the standpoint either of utility or beauty, these unrivaled forests are the keystone of the arch.”

During high floods the rivers carry enormous quantities of sand and

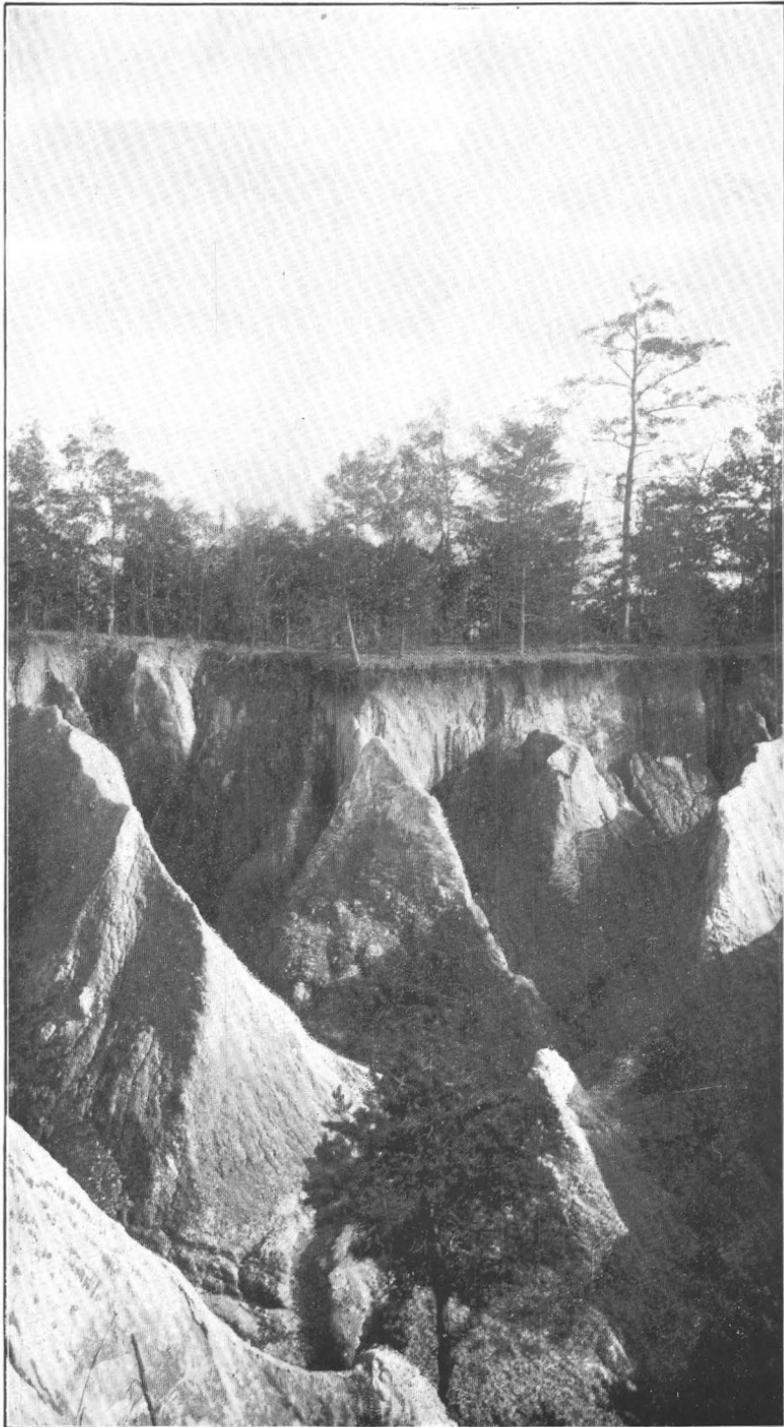
^aSee Pls. XVI, B, and XVII. H. A. P.



A. VIEW SHOWING BEGINNING OF WASH ON MOUNTAIN SIDE.



B. VIEW OF DEFORESTED HILLSIDE, SHOWING EFFECT OF EROSION.



WATER-WASHED GULLY IN DECOMPOSED GNEISS, McDOWELL COUNTY, N. C.

clay washed from the mountain sides. This material is deposited in great beds upon the cultivated lands along the rivers below (see Pl. XVIII, *A* and *B*), making future tilling impossible and ruining immense areas of arable land.

Inasmuch as the rivers are chiefly dependent upon their headwaters for supply it is impossible to overestimate the importance of preserving the forest cover on the mountain sides.

MINERAL RESOURCES.

No effort will be made to describe in detail the mineral resources of the region. The geological surveys of the various States and of the United States have published considerable literature on that subject, and further studies of it are now being made. Stated briefly, corundum abounds in certain localities. The mica of Yancey and Mitchell counties is widely known as among the best in the world, the deposits being so extensive as to furnish a large part of the world's supply. In a number of counties iron occurs in large quantities, and copper and other minerals have been mined to some extent. In the descriptions of the various drainage areas mention will be made of the more important mineral resources of specific localities.

HIGHWAYS.

The highways of the region are bad, having steep grades and being poorly surfaced. In many localities practically no work is put on the roads, and during certain seasons of the year they become almost impassable to wagons. This is largely due to the neglect of the inhabitants, for in most parts of the mountain districts excellent road materials exist, and with proper care and intelligence the highways could be maintained in good condition at moderate expense. Upon the mountain sides the rain water is allowed to run in the road bed, soon washing out great gullies and exposing the rocks, so that a horse is obliged to pick his way from side to side with great care and the rider to be constantly on the alert to prevent accident. Such a road is shown in Pl. XIX, *A*. The highway from Marion, N. C., to Sprucepine, illustrated in Pl. XX, is a typical mountain road of this region over which a wagon can pass, but with difficulty. In many cases, in order to avoid cutting a road on the slopes of the mountains, the stream bed is used as a highway, although usually exceedingly rough and at the time of high water dangerous to the traveler. Pl. XXI illustrates a road bed which has for years been used as a highway. Farther down the river valleys, where clays are more prevalent, the roads are often exceedingly muddy, it being a common occurrence for the wagons to sink hub deep into the mud. (See Pl. XIX, *B*.) There are a few remarkable exceptions, however, as, for example, the toll road from Linville around the base of Grandfather Mountain to Blow-

ing Rock, known as the Yonahlossee road and shown in Pl. XXII, and the road between Blowing Rock and Boone, both of which are excellent in grade and surface and show what can be done when the materials at hand are used with skill.

DRAINAGE BASINS.

In the course of the examination of the watersheds and the general investigation of the flow of the streams in the Southern Appalachian region which were carried on during the summer of 1900, many measurements of flow were made on the larger streams and on most of their upper tributaries, the results of which are contained in this report. The small Price meter was used in making measurements. There being few bridges in the region most of the measurements were made by wading. It was therefore impossible to make gagings of many of the streams at the time of high water.

In some respects the season was peculiar. Rain was abundant during June and the streams were moderately high during the early part of the summer. Later, however, very little rain fell, and most of the rivers and their tributaries were at an extremely low stage, as low, in fact, as they have been for a number of years. An effort was made to make more than one measurement at the same point on each stream. When the first measurement was made a bench mark was established, and the relative height of the water surface was measured at each successive gaging. Examinations were also made for high-water marks, and when the annual fluctuations of a stream could be determined they were noted. By means of these data a knowledge of the flow of the streams at various stages and of the relation that exists between the rise of the streams and their discharge can be obtained, though of course the only definite information we have is the discharge at the time of measurement.

On the larger streams gaging stations were established, as is the custom of the Survey, the height of the water surface being read daily on the gage and recorded by a local observer, and the measurements, which were made as often as practicable, being referred to the same gage. With these data a curve was plotted, using the gage readings as ordinates and the stream discharge, in cubic feet per second, as abscissæ. From this curve, the mean of the daily gage readings being known, the approximate daily discharge was interpolated. This method is described in detail in the annual reports of the Survey and in Water-Supply Paper No. 56.

The great difficulty encountered at these stations, which are on mountain streams, was to obtain measurements at the time of high water. After a rain the rivers rise rapidly, and as they fall as quickly, unless a person is near the station the high water will have passed before he can reach the point of measurement.



A. SAND AND CLAY DEPOSIT IN VALLEY.



B. SAND DEPOSITED UPON FARMING LAND BY RIVER FLOOD.



A. WATER-WASHED COUNTRY ROAD IN MITCHELL COUNTY, N. C.



B. UNIMPROVED ROAD IN VALLEY.

The following is a list of the gaging stations established in the basin:

Gaging stations established during 1900 on streams in Southern Appalachian region.

Stream.	Location.	Date established.
		1900.
New River.....	Oldtown, Va.....	August 5.
South Fork of New River.....	New River, N. C.....	July 29.
North Fork of New River.....	Weaversford, N. C.....	Do.
Yadkin River.....	Siloam, N. C.....	August 3.
Catawba River.....	Morganton, N. C.....	June 19.
John River.....	do.....	Do.
Linville River.....	Bridgewater, N. C.....	July 3.
Broad River.....	Dellinger, S. C.....	August 30.
South Fork of Holston River.....	Bluff City, Tenn.....	July 17.
Watauga River.....	Butler, Tenn.....	August 11.
Roan Creek.....	do.....	Do.
Elk Creek.....	Lineback, Tenn.....	August 5.
Nolichucky River.....	Chucky Valley, Tenn.....	September 20.
Pigeon River.....	Newport, Tenn.....	September 4.
French Broad River.....	Oldtown, Tenn.....	Do.

Besides the foregoing stations, which were established during the summer of 1900, the following gaging stations have been maintained for several years upon streams flowing from the Southern Appalachian Mountains:

Regular gaging stations of the Geological Survey on streams flowing from the Southern Appalachian Mountains.

- New River at Radford, Va., and at Fayette, W. Va.
- James River at or near Glasgow, Buchanan, Cartersville, and Holcomb Rock, Va.
- Roanoke River at Roanoke, Va., and at Neal, N. C.
- Dan River at South Boston, Va.
- Staunton River at Randolph, Va.
- Yadkin River at Salisbury and Norwood, N. C.
- Catawba River at Catawba, N. C., and at Rockhill, S. C.
- Broad River (of the Carolinas) near Alston, S. C.
- Saluda River at Waterloo, S. C.
- Tallulah River at Tallulah Falls, Ga.
- Tugaloo River near Madison, S. C.
- Savannah River near Calhoun Falls, S. C., and at Augusta, Ga.
- Oconee River near Dublin, Ga.
- Chattahoochee River at Oakdale and at West Point, Ga.
- Coosawattee River at Carters, Ga.
- Oostanaula River at Resaca, Ga.
- Coosa River at Rome, Ga., near Riverside, Ala., and at locks Nos. 4 and 5, Alabama.
- Toccoa River near Blueridge, Ga.
- Nottely River at Ranger, N. C.
- Hiwassee River at Charleston and Reliance, Tenn., and at Murphy, N. C.
- Tennessee River at Chattanooga and Knoxville, Tenn.
- Little Tennessee River at Judson, N. C.
- Tuckasegee River at Bryson, N. C.
- French Broad River near Asheville, N. C.

These stations cover every stream rising in the Southern Appalachian Mountains. Results of measurements will be found in the annual reports of the Survey.

HOLSTON RIVER.

PHYSICAL FEATURES.

The areas drained by Holston River comprise the basins of the North, South, and Middle forks of that stream, the Watauga, the Nolichucky, and the French Broad, including parts of southwestern Virginia, eastern Tennessee, and western North Carolina. The river is one of the largest of the streams which form the great Tennessee River. It rises along the western slopes of the Blue Ridge, in Smyth and Bland counties, Va., in three forks, known as the North, Middle, and South forks, respectively. The North Fork, from its position, receives no tributaries rising within any of the areas proposed for the projected Appalachian National Park, and for that reason, in view of the very large area necessary to be covered during the field season and the limited time in which to perform the work, it was not investigated. The areas drained by the Middle and South forks were quite thoroughly studied, and many direct instrumental measurements were made of their flow and of the flow of all streams tributary to them whose discharge was sufficiently great to admit of the use of a current meter, the minimum limit being, roughly, a little less than 1 cubic foot per second, depending largely on the form and character of the bed of the stream.

The physical conditions of the drainage basin vary greatly, the character of the country ranging from the gently rolling plain of the South and Middle forks, with its smooth, rounded, and grass-covered hills, to the grandest and mightiest mountain masses to be found east of the Rocky Mountains, such as the Unakas and the Black Mountains, with their numerous peaks rising more than 6,000 feet above sea level, and with steep and rocky slopes still clad in virgin forest. There are wide variations in the soil and in the general geologic conditions and structure, considerable variation in temperature and rainfall, and still wider variations in the character of the streams of the area, which include the brawling mountain torrents fed by perpetual springs, the puny wet-weather streams of the slate country, and the subterranean streams of the limestone regions. The entire area is part of the great Mississippi slope, of which the eastern boundary is formed by the Blue Ridge Mountains, on which all of the streams of this area rise, those of Virginia flowing to the southwest, through the great Valley of East Tennessee, those from North Carolina flowing to the northwest, through the Unakas, in grand and deep gorges and down the valley slopes to their union with the main stream.

The Unaka chain, the most prominent natural feature within the



MOUNTAIN ROAD NEAR SPRUCEPINE, N. C.



ROAD IN STREAM BED.

area, is a long range, the most massive of the Appalachians, its high crests forming the boundary between North Carolina and Tennessee. It is for the most part one single ridge, but occasionally it spreads out into a series of from two to four parallel ridges. The chain is continuous except that it is intercepted by the deep and rocky cuts of the tributaries of the Holston and the Tennessee. In Virginia it unites with the Blue Ridge. It forms large parts of Johnson, Carter, Washington, Greene, Cocke, and Unicoi counties in Tennessee. In Johnson County the ridges lie in such a manner as to completely encircle the great cove of the county, and in Carter County they nearly inclose the valleys. It has been said that the chain is a belt of parallel ridges, but in most of the Tennessee part of it the ridges are two in number, one being the main axis of the chain, the other lower and lying along the foot of the slope, though generally separated from the main range by long coves. This typical character does not always hold good, however, the greatest departure being in the country to the northeast of French Broad River.

In the northeastern corner of the State, north of Watauga River, in Johnson and Carter counties, the Unakas divide into three distinct ranges separated by wide and beautiful valleys. Seen from some points these ridges appear parallel, but in reality they are convergent toward the north, and near the Virginia line the Holston and the Iron mountains, the most western of the diversions, converge, and farther on, in Virginia, the two ranges unite in the long chain known as the Iron Mountains. The most easterly of these three ranges is the Stone Mountains, a long series of crowded ridges, along the crest of which runs a portion of the State line, extending from south of the Watauga and culminating in the grand and conspicuous summit of Whitetop. The middle range is the Iron Mountains, a long, straight ridge extending through Johnson and Carter counties—a portion of it forming for a long distance the boundary line between those counties—being separated from the Stone Mountains by the valley lands of the former county. Watauga River and Doe River have cut through this range, but it continues to be well defined until the southern part of Carter County is reached, and there it sinks away. South of the Watauga it is separated from the mountains on the east by a long and narrow valley known in its wider portion as Doe River Cove. The last and most westerly of the ridges is the Holston Mountains, which run out abruptly from the other ridges and terminate as abruptly a few miles north of Elizabethton, Tenn. They are separated from the mountains on the east by the curious, very elevated basin called Shady Valley and by the valley of Stony Creek.

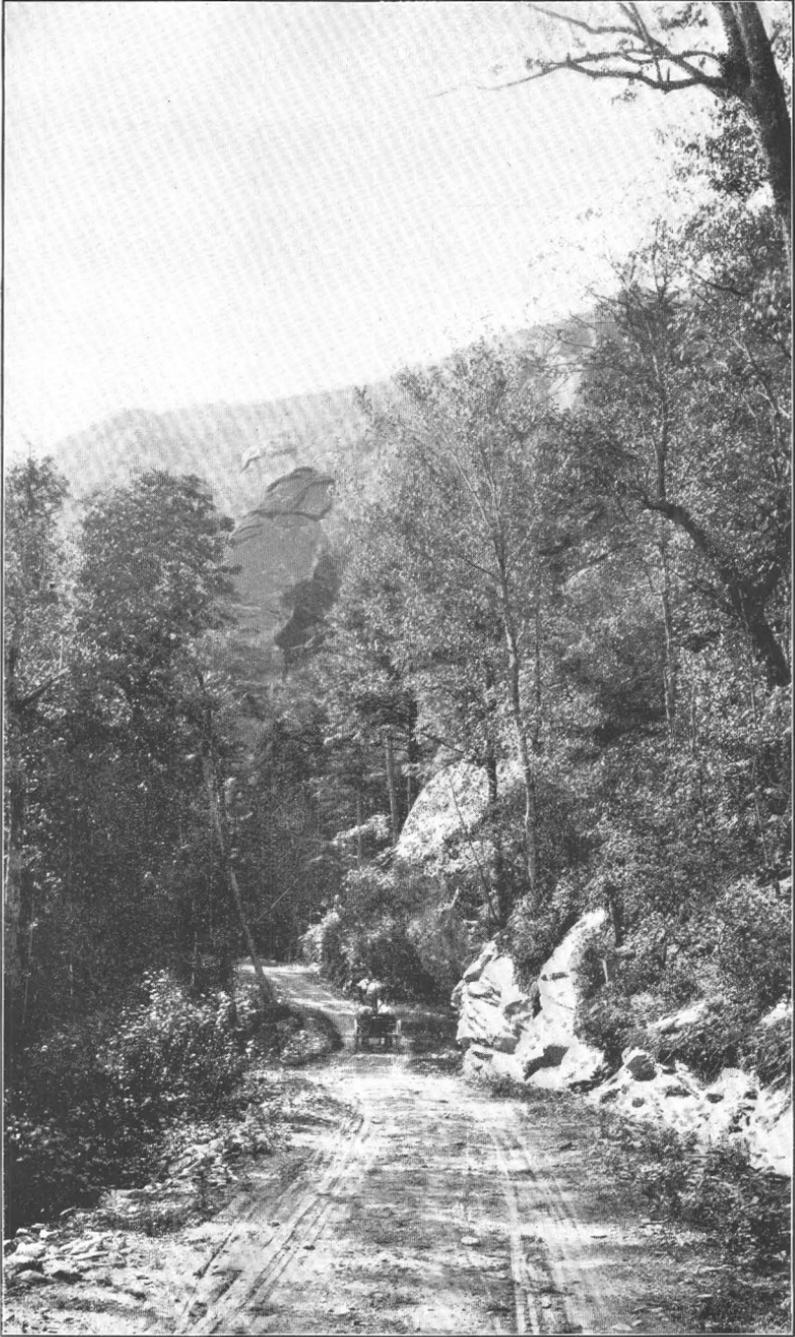
As a rule the Unaka ridges are forest clad. The higher summits, however, are frequently destitute of trees, owing perhaps to the high altitude and the consequent low temperature, but more probably to peculiarities of the soil. Such summits are called balds. Sometimes

they are a mile or more in diameter, and sometimes a chain or succession of them occurs along a ridge, forming a continuous bald for several miles. Roan Mountain is a bald of the latter class, and there are several others like it in the range. The most magnificent views in the mountains are obtained from these peaks.

Lying to the west of the Unakas is the great valley known as the Valley of East Tennessee. This broad and beautiful basin is a southward continuation of the famous Valley of Virginia. In Tennessee it has an extreme width of more than 50 miles. It is drained by the Holston and its tributary streams. The portion of the valley covered in the course of this investigation embraced parts of Sullivan, Carter, Johnson, Washington, Greene, and Cocke counties. The topography is composed largely of a series of parallel ridges, the axis extending in a northeast-southwest direction, making the country very rolling when viewed transversely. One of the most marked peculiarities of the region is the short and narrow ridges of slate which are apparent here and there over the area, sometimes occurring in short chains of slaty knobs. In Washington, Greene, and Cocke counties the valleys partake of the nature of the ridges and are short and broken. There are wide variations in the width of the stream valleys, some being sharp and V shaped, others several miles in width and very beautiful and fertile. One of the largest of the valleys is in Johnson County—Johnson County Cove, as it is sometimes called. Its form and position can be seen by reference to almost any map of the area. Below Mountain City it is divided lengthwise by Doe Mountain, an isolated sandstone ridge, but the parts are united again in the valley of the Watauga, which is said to have a larger area than any other valley of similar elevation in the State. It narrows to a point a short distance from the Virginia line, and is entirely inclosed by mountains, the Stone Mountains being on the east and south and the Iron Mountains on the northwest.

Lying between the Holston and the Iron mountains, just before they unite in Virginia, is the elevated basin called Shady Valley, also situated in Johnson County, and being much higher than the great valley just described, but having a much more limited area. The elevation is so great that the flora partakes of the character of that found in the northern regions of Canada. Iron of good quality and very fine white pine and spruce are found here. This valley is more fully described on pages 65 to 66, in the description of the area drained by Beaverdam Creek.

The rivers of the Valley of East Tennessee are wide and shallow, the waters clear and beautiful, and the tributaries numerous. There are two general directions of flow, the tributaries flowing to the northwest or the southeast and the main streams flowing to the southwest. The valley floor throughout is very level to gently rolling, composed of small and rounded hills with gentle, grass-covered slopes, leaving



YONAHLOSSEE ROAD, AROUND THE BASE OF GRANDFATHER MOUNTAIN, NORTH CAROLINA.

broad areas of level meadows or bottom land between them and dotted over with small tracts of hard-wood trees. From this general level the transverse ridges as a rule rise gently, although they are sometimes very rough and rugged and are almost entirely forested.

The area drained by Holston River in Virginia is entirely within the limits of Washington and Smyth counties, being the southeastern half of each county. The extreme southern and southeastern parts of the area are covered by the northward extension of the great Unaka chain known as the Iron Mountains. The extreme eastern part is covered by the slopes of the Blue Ridge and its outliers, the Pond and the Brushy mountains. On the north it is closed in by the slopes of Walker Mountain, a long ridge which separates the watersheds of the North and South forks of the stream. The general characteristics of these mountain areas are similar to those previously described for the Unaka chain in Tennessee, except that the peaks rise to less heights and are completely wooded. The geologic structure is, however, different, many of the mountains being capped with sandstone, the prevailing rock of the valley floor being limestone. The valley itself is much more broken, and in its upper part contains a much smaller portion of cleared land than the areas farther to the south, the natural consequence of the changed topography. However, the strip of level land bordering the South Fork on the south, the entire area between the South and Middle forks, except the slopes of the Pond and the Brushy mountains, and the area to the north of the Middle Fork as far as Walker Mountain are well situated for agricultural and stock-raising pursuits, are almost entirely cleared, and are in a high state of cultivation, being held at a very high valuation.

The part of the watershed in North Carolina, being the areas drained by the Watauga, Nolichucky, and French Broad rivers, is included in the counties of Watauga, Yancey, Mitchell, Madison, Buncombe, Henderson, and Transylvania, and is described at length in connection with the drainage basins of those rivers. The last four counties comprise the watershed of the French Broad. The first three counties—Watauga, Yancey, and Mitchell—occupy the entire width of the transmontane plateau lying between the western slopes of the Blue Ridge and the Unakas, and their surface is a bewildering confusion of mountain chains and spurs extending in every direction, without order or plan, and inclosing short and narrow valleys and inconsiderable areas of cleared land, except along some of the larger streams.

One of the distinguishing characteristics of the whole basin drained by Holston River is the occurrence of small closed basins or sinks, which are found in great numbers on the low divides between the various tributary watersheds. They are so numerous, in fact, that in many localities it seems impossible that any of the rainfall over areas of a square mile or more can find its way into the streams. Certainly

there are no channels visible, and in many cases water was seen standing in pools from 50 to 100 feet in diameter, indicating that there is no subterranean passage through which the water finds its way to the streams. Other sinks are dry, except after heavy rains. In some instances the farmers have rendered the bottoms of these natural basins impervious, and the collected water is used for cattle.

Springs are numerous over all the basin, ranging in size from a discharge of several cubic feet per second to less than a gallon per minute. Many of the smaller streams seem to be fed entirely from this source. In this connection may be noted the fact that a number of streams which at some point in their course sink below the surface of the ground, after flowing there for distances varying from a few yards to a half mile or more reappear on the surface. Some streams were noted which while discharging no water into the main stream carried a considerable quantity a short distance above their mouths, the water sinking gradually into the earth as the river was approached. It is said that the Middle Fork loses a quantity of water in this way, and from the character of the country rock this seems by no means improbable.

RAINFALL.

Little definite information can be given regarding the annual rainfall in this basin, but it is well known that throughout the region there is no lack of moisture, showers frequently falling on the mountains when there is not a cloud over the valley. The rainfall in the valley to the west is between 40 and 45 inches per annum, and that on the mountains is certainly greater. Throughout all the area covered by the investigation there is a lack of records whereby the rainfall can be even approximately determined, most of the records obtainable being very fragmentary. Those at Knoxville best represent the average condition prevailing over the valley, though the Chattanooga records may be of service in determining the average rainfall. The maximum precipitation recorded at Knoxville is 73.8 inches per annum, which is 146 per cent of the mean, and up to 1896 the minimum was 37.4 inches, or 74 per cent of the mean. At Chattanooga the maximum is 68.1 inches per annum, or 126 per cent of the mean, and the minimum is 37.2 inches, or 69 per cent of the mean. It may be stated that the variation between the maximum and minimum rainfall is at least as great as this throughout the region, the precipitation in dry years being somewhat less than 50 per cent of the mean.

Droughts are rare and as a rule of short duration. The most notable one occurred in the summer and autumn of 1900, when throughout the entire country, both in the valleys and on the mountains, the drought was very severe and long continued, producing the lowest known stage of flow in all of the streams. During the winter the higher summits are almost entirely covered with snow

AGRICULTURE.

As might be expected from the comparatively scanty population and the inadequate transportation facilities, agriculture and stock raising are the principal pursuits. In the valley of Holston River, where the country is comparatively level, there are many fine farms, which are held at a high valuation, and the community seems extremely prosperous. Although the areas drained by the Watauga and the Nolichucky are rough and mountainous, yet the lower slopes afford a fine cattle range, and the valleys are sufficiently extensive to produce the necessities of life for the inhabitants.

MINERALS.

The mining possibilities are very large, although little has been done to develop this source of wealth. In the localities where mines have been opened the work seems to have been carried on in a very spasmodic way. Iron ore of great purity is found in abundance in many places, and has been mined to a considerable extent at some localities, the ore being reduced at the furnaces at Bristol, Johnson City, Embreville, and Cranberry within the basin, or shipped to Pulaski and near-by points outside of it. Copper, lead, zinc, fluor-spar, gypsum, gold, salt, barytes, mica, corundum, and gem stones all occur in quantity, and some have been mined at large profit.

LUMBER.

The lumber interests also are of great importance, the area containing many large tracts of fine timber, from which several large sawmills draw their supplies, while small portable mills are found over all the area. A large amount of tan bark is stripped near the railroads, the stocks being sometimes worked into cord wood, but more often allowed to rot where they fall.

TRANSPORTATION.

The transportation facilities over the greater part of the area are pitifully inadequate. The Norfolk and Western Railroad skirts the northern edge of the basin of Holston River proper, the Knoxville branch of the Southern Railway follows along the French Broad, there is a narrow-gage road from Johnson City to Cranberry, a small standard-gage road has been constructed from Bristol to Butler and is now being extended up the valley of Roan Creek toward Mountain City, while another road is being built from Abingdon to Damascus, from which place it will extend up Beaverdam Creek and into the Shady Valley, and the Ohio River and Charleston Railroad has recently been extended along the Nolichucky as far as the mouth of Caney River. In by far the greater part of the area, however, the only means of

transportation is by wagons drawn over the mountain roads, which are generally very rough and steep.

SOUTH FORK OF HOLSTON RIVER.

PHYSICAL FEATURES.

The South Fork of Holston River rises on the western slopes of the Blue Ridge, in Smyth County, Va., between the slopes of the Brushy Mountains on the north and the Iron Mountains on the south. It is formed by the junction, in a broad stretch of valley land, of Slemo and Cressy creeks, and flowing in a general southwesterly direction is joined by the Middle Fork about 6 miles southeast of Abingdon, Va. The stream below this junction and until the junction with the North Fork is still known as the South Fork. Below the latter junction it is known as Holston River.

The headwaters of the South Fork are at an altitude of about 2,800 feet, those of the Middle Fork at an altitude of about 2,900 feet, the elevation at the junction being about 1,800 feet. The altitude at the junction of Slemo and Cressy creeks is about 2,575 feet. The distance between the latter junction and the junction with the Middle Fork is about 29 miles in a straight line, and the average slope of the country about 27 feet to the mile. Following the course of the river, however, this distance is about 36 miles, and the average fall between 21 and 22 feet to the mile.

Although the basin is, broadly speaking, a plateau, it is not to be inferred that it has not some very sharply marked mountain ridges. The axes of these ridges extend in a northeast-southwest direction, approximately parallel to the course of the principal streams, and the buttressing spurs of the Iron and the Stone mountains serrate the southern edge with a series of high and jagged ridges. Away from these, however, the country is composed of a series of low, broad swells and wide, flat valleys, all of the slopes being gentle and covered with grass not unlike the famous blue grass of Kentucky. The soil seems very fertile, and good crops of corn, wheat, oats, and hay are produced.

For convenience in describing this large area, the country has been divided as follows: (1) Area drained by the South Fork below junction with the Middle Fork; (2) area drained by the South Fork above junction with the Middle Fork; and (3) area between the South and Middle forks. The area drained by the Middle Fork is described on pages 69 to 77.

AREA DRAINED BY THE SOUTH FORK BELOW THE JUNCTION WITH THE MIDDLE FORK.

This area lies entirely within the eastern half of Sullivan County, Tenn., and to the north and east of Bluff City, the western limit of

the investigation. Throughout the basin occur many small closed basins or sinks, ranging in size from perhaps 50 feet in diameter to areas covering several acres. In many of them water was seen standing to a depth of several feet. Others bore traces of having recently contained water, while others were well drained. These basins are not indicated on any map of the area, and computations of run-off will be much complicated by them, as the amount of water kept back from the streams is a totally unknown quantity. The country rock is a limestone, much jointed and laminated in places, very massive in others, and these sinks are characteristic of that formation. Ledges of slate are numerous. The limestone is gray to black in color, and strikes to the northeast, the dip being frequently as great as 85 degrees. It is of very good quality, being suitable for quarrying into building stone, and a considerable quantity is used locally, none, however, being quarried for shipment, so far as could be learned. Perhaps the the most important use to which this stone is put is for flux at the various blast furnaces. Small amounts are also burned into lime, which is used in the local building operations or is applied to the land. A small quantity is also used as a road material, but this quantity is very small indeed, for little attention is paid to the roads, which as a rule are poorly graded and ill kept. The soil is in places a red clay impervious to water, but seems for the most part to be a gray, yellow, or brownish loam, and is very fertile.

The country on the south side of the river near Bluff City is pre-eminently suited to agriculture and to stock raising, being made up of a series of very low and broad ridges and small swells or hills rising from 25 to 30 feet above the level of the valleys between, all forming the surface of a plateau elevated 200 feet or more above the river level. The hillside slopes are gentle, ranging from 5 to 10 degrees, and there are large areas of level land. The general impression of the country when viewed from a distance is that of a plain, but at closer range it is seen to be very gently rolling. By far the greater portion (about 80 per cent) of the land is cleared and either cultivated in corn or wheat or sodded in grass, the areas of each being about equal. The forest growth occurs in small and segregated areas, too small to have much effect on the run-off from the surface. The character of the growth varies, being in some parts almost exclusively pine, while in others and over the larger part of the area oak and chestnut are the predominant trees. Many other varieties, however, are found in abundance, and occasionally the finer cabinet woods, such as walnut, curly maple, and curly birch. As the main stream is approached the country becomes much rougher, the small stream valleys being more deeply carved and the hillside slopes steeper. The descent from the broad upland plateau to the river plain several hundred feet below is very steep.

Ascending the river the uplands for several miles above Bluff City

are similar to those described, except that possibly the proportion of cleared land is slightly less; but it is estimated to be about 75 per cent of the area, and at least half of it is in grass. Throughout this part of its course the river runs in a channel carved through the soft limestone country rock and into the harder and more resistant slates, producing a very rough bed, the slate being much jointed and laminated and projecting in jagged ridges across the course of the stream; but the fall seems well distributed, there being little noticeable concentration at any point.

Going up the river the portion of cleared land seems to gradually decrease, until near the mouth of Weaver Creek it has diminished to one-half or less. This is a consequence of the greatly changed topography, the plateau character of the uplands having been largely lost, sharp and rugged forest-covered hills having taken the place of the small, round, grassy knolls and wide, level bottoms seen farther down the stream. Near the mouth of Weaver Creek the mountains close in on the river, and from that point to and above the mouth of Morrills Creek all of the basin lying to the south of the stream is very rough. There is no arable land along the river, and the hills are wooded to the top.

On the south side of the stream the country draining into the river below the junction with the Middle Fork is composed of the basins of Jacobs Creek and Denton Valley Creek. Near the river the country is more gently rolling than farther downstream, and as a consequence is more largely cleared, but of the whole area drained by Jacobs Creek probably only about 10 per cent is cleared, most of it near the mouth. A short distance up the stream the country becomes broken and rough and is largely in woodland. For about 3 miles above the mouth of Denton Valley Creek a considerable portion—possibly one-third—of the land is cleared, being largely devoted to grazing. The hillside slopes vary from 15 to 30 degrees. These slopes show a great deal of exposed limestone. Above this 3-mile stretch the country rapidly becomes very rough and rugged and is totally forested.

On the north side of the stream the topography differs slightly from that on the south side, consisting entirely of small hills and rounded swells, with a larger proportion of cleared land, ranging from about two-thirds over the lower part of the basin to three-fourths or more near the Virginia line and around Bristol, while over some of the small drainage basins, such as that of Sinking Creek, more properly known as Beidelmans Creek, from 85 to 90 per cent of the land is cleared and under cultivation or in grass or pasture. The same is true of the area drained by Thomas Creek and of the area known as the Holston Valley, the country being almost level and almost entirely grass covered, the soil being for the most part gray and porous, though some areas of red clay were seen. On the north side of the river, near

Bluff City, zinc is found in paying quantities and mines are now being opened. There are numerous deposits of iron ore throughout the area, and the same is said to be true of all the counties bordering the Unaka Mountains. Over the valleys of Spring Creek (the first tributary entering from Virginia), Wolf Creek, and Fifteenmile Creek the general character of the country is the same as that just described, probably more than 75 per cent of the area being cleared, the soil seeming to be porous and very fertile. Hay and wheat are the chief agricultural products, and as elsewhere in the region a great many cattle are raised. Wherever timber occurs it is hard wood, pine being very scarce. Near Ruthton the proportion of forest land is greater than in any part of this area, and much timber is being cut, forming a profitable industry. Lumbering becomes more and more a source of revenue as the river is ascended.

AREA DRAINED BY THE SOUTH FORK ABOVE JUNCTION WITH THE MIDDLE FORK.

This part of the drainage basin lies almost entirely on the south side of the stream—the area between the forks being too small for the formation of streams of appreciable size—and includes large areas of very mountainous country which is densely wooded. From the junction with the Middle Fork to the mouth of the Laurel Fork the basin is narrow, being shut in by the northward extension of the Holston Mountains, and excepting the land immediately bordering the stream the country is rough and rugged, with steep slopes densely forested, the valleys being extremely narrow and containing little if any cleared land, the land that is cleared being confined, so far as could be ascertained, to the narrow strip bordering the river, and therefore constituting a very small part of the whole.

Above the mouth of the Laurel Fork the mountains recede somewhat from the stream, the strip of arable land becomes wider, and cleared areas are to be found in the basins of some of the tributaries, as on Rosenbaums Creek, where the proportion of cleared land is between two-thirds and three-fourths, while of the whole area lying between the river and the road from Damascus to Holstein Mills about one-third is cleared. The area to the south of the road is entirely in forest, and the slopes are steep and rocky, the country rock being still a limestone formation.

Many sawmills are located near the headwaters of some of the small tributaries, and are engaged in cutting the hard-wood timber. There are also one or two mills along the stream, but they are cutting only a few hundred feet each day.

Widner Creek, Rush Creek, Poge Creek, Mill Creek, Grose Creek, and St. Clair Creek, all tributaries from the south, are small streams draining narrow and confined valleys and rough, mountainous, and forest-covered slopes, the small proportion of cleared land in the basin of each being confined to the narrow strip next to the stream, the

country being rather inaccessible, as roads are few. There is much timber, but, owing to the roughness and steepness of the mountain slopes it is exceedingly difficult to lumber it, so that up to the present time very little has been cut.

There is one notable exception to the general character of the country along the river, viz, the area known locally as the St. Clair Bottoms, situated on both sides of the South Fork between Holstein Mills and the Washington County line, extending back 1 or 2 miles on each side of the stream and embracing a large area of very beautiful grazing land, a small part only being cultivated in corn and wheat. These bottoms are broad, and from them the uplands rise very gently, the area being practically all cleared. The country rock is a limestone, a small quantity of which is burned for building purposes and to apply to the land.

Above Holstein Mills the mountains close in again and as a consequence the area is more broken and rough. Very little cleared land is to be seen either along the river or away from it until the head of the stream is reached, when the mountains again recede, leaving the broad and fertile area known as the Rye Valley, which extends from a little below Dickey Creek to and above the junction of Slem and Cressy creeks, and is rimmed about by high and steep mountain slopes. This valley is very broad and gently rolling, and is almost all cleared and in grass. Dickey, Slem, and Cressy creeks are small streams draining narrow valleys and areas of steep mountain slopes where the proportion of cleared land is small above the limits of the broad valley just described.

AREA BETWEEN THE SOUTH AND MIDDLE FORKS.

This area is a long and narrow strip, 5 or 6 miles in width at the widest part and about 29 miles long, measured from the headwaters of the two streams to the point of junction, and slopes from the crest of the Blue Ridge toward the southwest, the area being about equally divided between the drainage systems of the two forks.

From the junction of the streams to the slopes of the Pond Mountains the country is level or gently rolling, the hillside slopes being slight. The soil is largely a red clay quite impervious to water, though there are large areas of a light-yellow porous soil. The cleared land forms about three-fourths of the area and the wooded portions are too small and as a rule too widely separated to have much effect on the run-off.

South of Marion the large sandstone areas represented by the Pond and the Brushy mountains are all wooded and quite steep. Even where the timber has been cut away the smaller trees and underbrush have grown rapidly and cover the ground with a dense shade. Some of the slopes, however, are composed largely of a species of talcs, small angular fragments of the stone comprising the mass of the uplift, covering them in places to a depth of several feet, where the growth is sparse, consisting of small bushes and straggling trees.

RAINFALL.

The annual rainfall over the basin of the South Fork is comparatively large, averaging probably between 40 and 41 inches per annum, diminishing somewhat as the stream is ascended. Over all the basin the summer rainfall seems greater than that of any other season, heavy rain storms being of frequent occurrence, causing large and rapid rises in all of the streams. Severe droughts are relatively infrequent and are soon broken. The drought of the summer and fall of 1900 was said to be the most severe in the history of the region, and it is thought that the low-water gagings made at that time represent the minimum discharges of the streams.

FORESTS.

The forest growth of the basin is mostly oak, chestnut, and pine, with some spruce, walnut, maple, hickory, beech, birch, dogwood, cherry, ash, locust, and poplar, and still smaller quantities of other woods. There are important lumbering industries, notably those near Bristol, although throughout the area numerous mills, large and small, are working up the raw material. In many places large quantities of tan bark are stripped, much of it going to the great tanneries at Bristol. The chief industry of the region, however, is cattle raising, large numbers of which are shipped annually from this section.

MINERALS.

Iron ore is found at a great many points within the basin, and is being mined at some localities, although from some cause the business seems to be languishing, most of the furnaces being out of blast. Zinc is found near Bluff City, Tenn., and gold, barytes, and fluorspar are found in small quantities at various places. There are large deposits of gypsum in the valley of Walker Creek; sandstone, granite, and dolomite occur in small areas; and limestone of excellent quality is found in abundance everywhere. Near Marion, Va., the limestone is quarried in considerable quantities and is shipped to the alkali works at Saltville, Va., where there are extensive saline deposits.

TRANSPORTATION.

The basin is traversed by the lines of the Southern Railway as far as Bristol. The Norfolk and Western Railroad extends from that point the whole length of the basin, and the Bristol and Elizabethton, the East Tennessee and Western North Carolina, the Holston Valley, and the Ohio River and Charleston Railroad afford comparatively good communication with the greater part of the area.

DISCHARGE MEASUREMENTS.

During the investigation many measurements were made of the river and its tributaries, and one gaging station was established in

the basin, viz, at Bluff City, Tenn. The miscellaneous measurements made on the South Fork and also those made at the gaging station are given in the following table. The measurements made on the tributaries are given in the table on page 53.

Discharge measurements of South Fork of Holston River.

Date.	Locality.	Hydrographer.	Gage height.	Discharge.
1900.			<i>Feet.</i>	<i>Sec.-ft.</i>
July 17	Bluff City, Tenn.	E. W. Myers and L. V. Branch.	0.25	378
Aug. 16	do.	do	0.25	329
Sept. 25	do.	do	1.15	791
Nov. 8	do.	do	0.90	681
Dec. 27	do.	do	0.60	392
July 23	Below mouth of Middle Fork, Va.	L. V. Branch.	3.06	228
Oct. 3	do.	E. W. Myers	3.21	199
July 28	Below mouth of Laurel Fork, Va.	do	2.60	652
Oct. 3	do.	do	3.59	149
July 28	Above mouth of Laurel Fork, Va.	do	1.51	101
Oct. 3	do.	do		48
July 27	Rye Valley, Va.	do	6.96	20
Oct. 1	do.	do		5

NOTE.—At regular stations of the Geological Survey gages are installed by which the rise of the river is measured, an increase in the gage height representing an increase in the discharge of the stream. This is true of the measurements in the above table which were made at Bluff City, Tenn. In making the other measurements given in the table, however, bench marks were established and measurements were made, by means of a steel tape, of the distance from the bench mark to the surface of the water. In those cases, therefore, an increase in the gage height means a lowering of the water surface and a corresponding decrease in the discharge of the stream.

WATER POWERS.

A water power of considerable magnitude can be developed at Bluff City, Tenn., where the total available fall is between 15 and 20 feet. The only use of the power at present is by the Bluff City mill, a flouring mill having a capacity of 50 barrels per twenty-four hours, using a fall of from $5\frac{1}{2}$ to 6 feet, which with one 35-inch Victor turbine develops about 30 horsepower. Formerly there was a small cotton mill located here which used about 7 feet of the fall, but that is no longer in operation. A development of power could easily be made at this place, the river being narrow, with high bluffs on each side. The railroad facilities also are good.

Above the pond of the Bluff City mill the stream is comparatively placid until just below the mouth of Dry Creek, where there is a shoal having a fall of about 8 feet in 200 yards. The bed of the river is very rough, being crossed by several ledges of rock and containing many loose boulders. The banks are rather low, being only about 10 feet above low water.

McClellan's mill, the first mill on the river above Bluff City, is on the north bank of the stream about 50 yards above the mouth of Weaver Creek. It is a small combined sawmill, gristmill, and cabinet shop, using a small amount of power, which is obtained from an undershot wheel and a homemade tub wheel, both using a head of about 4 feet, practically all that is available. It is said that curly maple and curly birch are to be found here in considerable quantities, and that other fine cabinet woods abound.

There is one small shoal in the river between McClellan's mill and the mouth of Beidelmans Creek, but the fall is slight and the locality of no practical importance. At the time this stream was first visited, in the latter part of July, 1900, almost all of the small tributaries in this part of its course were practically dry, the largest carrying less than 0.5 second-foot. The stream itself between the points mentioned consists of a succession of still pools, seemingly quite deep, with a very low current velocity broken by short shoals where the depth of the water ranges from a few inches to about 1 foot, flowing over and among water-worn pebbles from 3 to 6 inches in diameter, with occasional rock ledges crossing, where the principal falls are found.

For some distance upstream from the mouth of Thomas Creek the hills on the north side rise rather steeply from the river's edge to a height of several hundred feet, and the valley on the south side is much narrower than those heretofore described. The country rock along the stream is a much jointed and laminated gray or black slate, striking to the northeast and dipping almost vertically. The river flows over the upturned edges of this slate, making a very rough channel, but one in which the fall is well distributed, there being little noticeable concentration at any locality.

About 200 yards below the mouth of Riddle Creek there is a small mill, known as Rosenbaum's mill, which diverts a few second-feet of water from the river by means of a low and loosely piled rock wing dam, a fall of about 5 feet being obtained through a race 150 yards long.

About 1 mile below the mouth of Fishdam Creek and just above the mouth of a small unnamed branch there is a fall of 5 feet in 300 feet, over a rough and rocky bottom, composed of angular boulders and rock ledges. There are high and rocky bluffs on the north side of the stream, but on the south side the banks rise to a height of about 10 feet, and then a broad meadow slopes gently away. The facilities for building a good dam and a race at this point are excellent.

Just below the mouth of Fishdam Creek is one of the finest mill sites seen on the river. The current is divided by a small island, at the head of which a low loose-rock wing dam has been built, diverting a small part of the current. Another dam has been constructed about 30 yards above the foot of the island, a total fall of 9 feet being thus obtained, which is used by a small sawmill and gristmill requiring probably about 2 horsepower, which is developed by a small flutter wheel. This mill is said to have a capacity of 600 feet of lumber or 40 bushels of corn a day. Power in large quantity could very easily be obtained here, and although at present the locality is somewhat inaccessible, the graded way for the Holston Valley Railroad passes the mill and the track construction work is only a few miles distant.

Fishdam Creek enters the river at the elbow of a great bend known

locally as the Horseshoe Bend. If the river be followed the distance around this bend is about 2 miles, but the distance across the narrow point of the neck is only about 200 yards. This neck is low, being at its highest point only from 40 to 50 feet above river level. From water to water across the neck there is a fall of between 25 and 30 feet, as determined by the aneroid barometer. It is stated that this neck has been leveled over and the difference in elevation in the water surfaces on the two sides determined to be 26 feet. Should it be desired to develop this power, a tunnel or an open canal could be made across the neck and all or a part of the flow easily be turned through it. On the north prong of the bend the river is rather wide, but a low dam could easily be built, and there are large areas of well-protected bottom land, lying well above high-water mark, which would afford ample room for the necessary buildings. The country rock here is a much laminated and jointed slate, not suitable for building purposes.

The next shoal on the river is just above the mouth of Sharp Creek and the Shady Ford. The river here is full of islands large and small, and the fall is heavy, being about 20 feet in a distance of less than a half mile. The water could easily be carried along the southeast bank and used where desired along the river; or by a short extension the race might be carried around a small hill and Sharp Creek be used as a tailrace. The west bank is high and rocky, with numerous bluffs, and large quantities of stone suitable for rough building operations could be obtained from it. Plenty of timber is to be found in the immediate vicinity.

Some distance above this shoal and about a half mile below the mouth of Jacobs Creek there is a shoal having a fall of 6 feet in 200 feet, with a broad bottom on the west side and a high, rocky bluff on the east side. This power, however, is not considered of importance.

From this point to the junction with the Middle Fork the river could not be closely followed, but several localities with falls of between 6 and 7 feet were noted, the first one about 3 miles below the forks. About a half mile above this fall there is a similar shoal, about 1 mile below the forks there is another, while immediately above the forks there is one having a fall of about 8 feet in 100 yards which could easily be developed, as the banks are very high and steep. The bed of the river is in solid limestone and seemingly is very rough, but the stone in the bluffs quarries well, and a considerable quantity has recently been taken out to construct the piers for the bridge of the new railroad from Abingdon to the Shady Valley, which crosses the river at this point.

About a mile above the junction with the Middle Fork is Glenn's mill, a gristmill using about 24 horsepower, which is developed by a 24-inch turbine working under a head of 7 feet. There is a loose rock wing dam which turns a small part of the water behind an island, at the lower end of which a log dam $7\frac{1}{2}$ feet high has been built, from

which a wooden flume 100 feet long carries the water to the mill. There is never any lack of water at this point, and high water interferes with the operation of the mill not more than four or five days in the year on an average.

Above this point there is no noticeable concentration of fall on the South Fork until the mouth of the Laurel Fork is reached, the fall, though large, being well distributed.

About a mile above the mouth of the Laurel Fork is the Rambos mill, a small gristmill using an 8-foot fall and an unknown amount of power, sufficient, however, to operate three sets of stones. The dam is of timber frames planked over and is about 3 feet high and 150 feet long. It turns a small part of the water into a race about 200 yards long. The mill is old and considerably out of repair.

From this point up to about 3 miles below the village of Friendship there are no mills on the South Fork, though several small mill sites were heard of which in the past had been occupied by small gristmills which have been washed away by the floods to which the stream is subject. About 3 miles below Friendship was the best site heard of on this part of the river and the only one visited. This is known as the Buchanan site, and it is stated that there was formerly a very good gristmill here, but nearly all vestiges of it have disappeared. The fall used was about 12 feet, though a much greater fall could be made available by the construction of a suitable dam, which could be made from 40 to 50 feet high without flooding any valuable land.

A short distance above Friendship is Vail's mill, a combined sawmill, gristmill, and planing mill, using 78 horsepower, which is developed by three Success turbines of 24, 27, and 30 inches diameter, respectively, all working under a head of 12 feet. The miller at this mill stated that he had measured the river at its lowest stage and found a flow of 8,000 cubic feet per minute. The dam is of timber frames planked on the upstream side, 12 feet high and 144 feet long, forming a pond 500 yards long. The sawmill has a capacity of 6,000 feet B. M. per day, and the gristmill a capacity of 30 barrels. The year round there is plenty of water to run all of the machinery in this mill at the same time. It is estimated that with a head of 12 feet the river at this point has a flow sufficient to develop 145 net horsepower, and that from this point to the mouth of the Laurel Fork 100 horsepower could be developed every half mile.

About 4 miles above the Vail mill is Love's mill, located just below the Smyth County line. This also is a combined sawmill, gristmill, and planing mill, and is said to use 36 horsepower, developed by a 21-inch Success turbine rated at 20 horsepower when working under a head of 9 feet, and three wooden tub wheels developing a total of about 16 horsepower. The dam is of timber frames planked on the upstream face, and is in fair condition. It is 9 feet high and 150 feet long. It backs the water a distance of three-fourths of a mile, there being little slope in the river above the dam but a considerable fall

just below it. There is no race, a wooden flume 60 feet long carrying the water from the dam to the wheels.

The next mill on the river is the St. Clair roller mill, located about 2 miles below the Holstein mill, at Holstein Mills, in the area known as the St. Clair Bottoms. There is a fall of about 10 feet at this place, and the power used is developed by one 20-inch Success turbine, rated at 20 horsepower; one 35-inch Leffel wheel, Standard pattern, rated at 25 horsepower; and one 20-inch Burnham Brothers' wheel, rated at 20 horsepower; making a total of 65 horsepower when all of the machinery at the mill is in operation. The dam is a timber crib structure planked over on the upstream face, 7 feet high and 100 feet long, backing the water about 500 yards. The race is 200 yards long and gives a fall at the wheels of 10 feet. The mill is rated at 45 barrels per day and has a capacity of between 200 and 300 feet of lumber. At the lowest stages of flow there is not enough water in the river in this part of its course to operate all of the machinery in the mill at the same time.

The next mill on the stream is the Holstein mill, a combined sawmill and gristmill, evidently very old and greatly out of repair, using a fall of 12 feet and an unknown amount of power. This site is a very fine one for a small plant. The dam is of timber frames planked on the upstream face, and is very leaky. It is 12 feet high and nearly 200 feet long. There is no race, a short wooden flume leading the water directly to the wheels, two homemade affairs built on the turbine principle and yielding an unknown amount of power.

About 100 yards below this site is the site of an old woolen mill abandoned about ten years ago. Here there was a 9-foot dam about 150 feet long. At first two small turbines were used, but these required so much water that a race was dug from the dam of the upper mill, and a breast wheel 14 feet in diameter and 9 feet face was installed. This site is said to be one of the best on this part of the stream, suitable for any kind of a mill but particularly adapted for a woolen mill. The mill property includes dwelling houses, school, and church, all in good repair. The mill building has been torn down, however, and any power development would have to be made from the beginning. The valley above this mill is more hilly and is narrower than that below, which, particularly in the part known as the St. Clair Bottoms, is very broad, being 4 miles or more wide and extending back in a gentle rise to the foot of the mountains, with practically all of the land cleared.

Above this there are no mills on the stream until the Rye Valley is reached. In the upper part of that valley there is a small gristmill operating one pair of stones by a large overshot wheel and using a very small amount of power. It is only 5 miles from this mill to the head of the stream, and above it the river is too small to furnish power in appreciable quantities, although throughout the upper part of the stream, from the St. Clair Bottoms to the head of the river, the

fall is very great, the stream being almost one continuous rapid. As determined by the aneroid barometer the fall between the end of the big bend immediately below the Rye Valley and the first ford below—a distance of about 1 mile—is 20 feet; between that point and the mouth of Pomer Creek it is 30 feet; between Pomer Creek and the river surface 2 miles above Holstein Mills it is 140 feet; and between the latter place and the ford below the old woolen mill—a distance of about $2\frac{1}{2}$ miles—it is 150 feet. Through the St. Clair Bottoms the fall is much less, but it is still large, and there are many places where falls of from 10 to 15 feet could be utilized by the construction of dams of suitable height.

TRIBUTARIES OF SOUTH FORK OF HOLSTON RIVER BELOW
JUNCTION WITH THE MIDDLE FORK.

DISCHARGE MEASUREMENTS.

During the investigation the drainage basins of all the important tributaries of the South Fork were visited and measurements were made of most of them. The results of the measurements on the tributaries below the junction with the Middle Fork are given in the following table, in order upstream:

Discharge measurements of tributaries of South Fork of Holston River below junction with the Middle Fork.

Date.	Stream.	Locality.	Hydrographer.	Gage height.	Discharge.
				<i>Feet.</i>	<i>Sec.-ft.</i>
1900.					
Sept. 25	Hatcher Creek	One-half mile above mouth, Tennessee.	E. W. Myers	5.92	0.34
July 20	Sinking Creek	One-half mile above Paperville, Tenn.	L. V. Branch	3.60	3.48
July 29	do	At mouth, Tennessee	E. W. Myers	4.92	11.00
Sept. 25	do	do	do	4.42	9.09
Do.	Thomas Creek	Below railroad bridge, Tennessee.	do	do	2.48
July 20	Riddle Creek	At mouth, Tennessee	do	12.19	2.00
Sept. 25	do	do	do	11.13	3.00
July 20	Jonah Creek	do	L. V. Branch	11.06	4.00
Sept. 25	do	do	E. W. Myers	11.42	4.00
July 20	Fishdam Creek	do	do	5.25	5.85
Sept. 26	do	do	L. V. Branch	5.28	2.47
July 21	Sharp Creek	do	E. W. Myers	5.36	1.18
Sept. 26	do	do	do	5.33	1.19
July 21	Jacobs Creek	do	L. V. Branch	9.10	2.07
Sept. 27	do	do	E. W. Myers	do	2.00
July 21	Spring Creek	1 mile above mouth, Virginia	L. V. Branch	0.90	13.00
Sept. 27	do	do	E. W. Myers	do	10.00
July 21	Wolf Creek	Lower ford of main road up the river, Virginia.	do	2.35	7.00
July 23	do	do	L. V. Branch	2.36	7.00
Sept. 27	do	do	E. W. Myers	2.21	12.24
July 21	Denton Valley Creek.	At mouth, Virginia	L. V. Branch	5.73	6.00
Sept. 27	do	do	E. W. Myers	5.73	4.04
July 23	Fifteen mile Creek.	do	L. V. Branch	4.45	7.37
Sept. 27	do	do	E. W. Myers	4.23	10.46

NOTE.—In making the measurements recorded in the above table, bench marks were established and measurements were made, by means of a steel tape, of the distance from the bench mark to the surface of the water. An increase in the gage height, therefore, means a lowering of the water surface and a corresponding decrease in the discharge of the stream, the reverse of the results at the regular stations of the Survey, where gages are installed and where an increase in the gage height represents an increase in the discharge of the stream.

On the following pages are given brief descriptions of the drainage basins and water powers of the principal tributary streams in this portion of the basin of the South Fork, in order upstream.

INDIAN CREEK.

The first tributary investigated was Indian Creek, which enters from the south, near Bluff City, Tenn., and has a total length of about 7 miles, following its windings. The country rock observed over the basin was a slate, brownish-black or gray in color, much laminated and broken, striking N. 70° E., and dipping sharply to the south, from 80 to 85 degrees in some cases. As the mouth of the stream was approached ledges of limestone made their appearance on the tops of the hills.

For the first 2 or 3 miles above the mouth the topography consists of low, rounded hills and broad, flattened swells, cleared to the top for the most part, and under cultivation in grain or grass, the area being about equally divided between those products. The woodland in this part of the basin amounts to only about 10 per cent of the area, but as the stream is ascended the hills are higher and more rugged, with steeper side slopes, and the proportion of cleared land is much smaller, being not more than one-third in the upper part of the basin. Over the lower part of the area the woods are composed almost entirely of hard-wood trees, but near the headwaters these give place to pine.

The fall of the stream is large, being between 450 and 500 feet, averaging between 65 and 70 feet to the mile. Very little of it is utilized, however, but there are three small mills, each using from 10 to 12 feet and operating one pair of stones by means of overshot wheels. Although these three mills use a very small amount of power, at the time the stream was first visited, in July, 1900, it was carrying too little water to operate them. The flow at the mouth was estimated to be about 1 cubic foot per second, though it could not be measured, owing to the shape of the channel. The hillside slopes vary from 15 degrees near the mouth to 50 or 60 degrees near the head of the stream.

In the first 2 or 3 miles above the mouth of the creek traces of three well-defined stream terraces were observed, the upper one being the uplands, the second one a narrow strip of level land lying from 20 to 25 feet above the present level of the stream, following its course but from 100 to 150 yards distant and sloping down very sharply to the level of the present bottom lands, which constitute the third member of the series. The descent in many cases is almost vertical.

Between the mouth of Indian Creek and the Dry Branch, the next tributary upstream, is an old mill known as Worley's mill, not now in operation, which was run by water from a big spring or sunken creek. At the time this stream or spring was visited it was carrying a quantity of water too small to operate the mill, but the discharge was estimated to be approximately 2 second-feet.

DRY CREEK.

Dry Creek, or more properly the Dry Branch, is the next tributary above Indian Creek, and like that stream it enters the river from the south. It has a total length of about 4 miles. The drainage area, which consists almost entirely of gentle swells and small grass-covered slopes or hills, is largely cleared land. At the time the stream was visited it was estimated to be carrying about 0.25 second-foot, the amount being too small to measure.

WEAVER CREEK.

Weaver Creek, the next tributary entering from the south, has a total length of between 5 and 6 miles. The part of the drainage basin lying near the river is very similar to the basins of Indian Creek and the Dry Branch just described, but as the stream is ascended the country becomes rapidly more steep and broken, on account of the rising spurs of the Holston Mountains. It is estimated that two-thirds of the total area drained by this creek is cleared land, the the greater part of it being grass covered. The discharge was estimated to be about 0.5 cubic foot per second, the quantity being too small to admit of measurement with a current meter.

HATCHER CREEK.

The next tributary is Hatcher Creek, locally known as Tow String Creek. At the time of the first visit, in July, this stream was dry, carrying no water for a mile or more above its mouth; but at the time of the second visit, September 25, although the stream discharged no water into the river it was carrying 0.34 second-foot about a half mile above its mouth. This flow, however, sank gradually into the earth within a distance of about 100 yards. The discharge was gaged just above this sink. It seems probable that this stream would begin to discharge water into the river when carrying a small quantity more than at the time of measurement. Its flood discharge is about 4 feet, and like the other streams in the region it rises and falls rapidly.

A great part of its drainage basin is in forest, and the character of the topography is much bolder than that of the areas lying farther to the west, the hills rising higher and the slopes being much steeper.

MORRILLS CREEK.

The next stream entering the river is Morrills Creek, which is about 6 miles long and drains a larger area than any of the foregoing tributaries. Near its mouth the character of the topography is similar to that of the other basins described, but as the stream is ascended the country becomes very rough and broken and the hillside slopes very rough, rocky, and steep. There is much cleared land near the river,

but so far as could be ascertained there is none near the headwaters. Despite its large drainage basin, the amount of water carried by this creek at its mouth at the time it was visited was too small to admit of measurement with a current meter, but it was estimated to be about 1 cubic foot per second.

SINKING CREEK.

The next tributary—the first of importance entering from the north—is Sinking Creek, more properly known as Beidelmans Creek, for Sinking Creek is properly a small tributary of the latter stream. It has a total length of about 12 miles. The upper part of its basin, from Paperville to the head, is broad and flat, consisting of low ridges and flattened swells cultivated to the top, from 85 to 90 per cent of the area being cleared land. From Paperville toward the mouth, however, for about 2 miles the hills close in on the stream, there is considerable fall in the channel, and practically none of the land is cleared, the hillside slopes being too steep and rocky to admit of cultivation. Below this short strip the character of the country is similar to that of the upper part of the basin. The timber, which occurs largely in the 2-mile stretch just noted, is almost all hard wood, and lumbering is an important industry. So far as known there are no mines or minerals in the basin, though large deposits of iron ore are found not far distant.

There are a number of mills on Sinking Creek, all within the 2-mile stretch described, where the stream has cut its way through the Great Knobs, leaving a very rough and steep channel. The first one is about a half mile above the mouth of the creek and is known as Beidelman's mill. It is a small gristmill operating two sets of stones and using a fall of about 8 feet, the power being developed by a 14-inch turbine yielding about 10 horsepower. The dam is of wood, about 2½ feet high and 100 feet long; the race is about 100 yards long, in earth and wooden flume.

Some distance above this and a short distance below the village of Paperville is Nutty's woolen mill, which uses about 14 horsepower, developed by a 14-inch Little Giant double turbine working under a head of 13 feet, which could be increased to 16 feet. This mill operates one set of woolen machinery.

About 200 yards above Nutty's mill is Bruce's mill, which uses a fall of 35 feet on a 12-inch James Davis turbine yielding 12 horsepower and operating one set each of corn and wheat stones as well as sawmill and planing machinery. There is no dam at this mill, the water being turned directly into the race. There is plenty of water except when the mills above close down.

About 200 yards above Bruce's mill is the planing mill operated by J. T. Nutty, where about 14 horsepower is developed by a 13½-inch Burnham turbine working under a 17-foot head, which is used to

operate a full line of sash, door, and blind machinery. The dam is $3\frac{1}{2}$ feet high and 36 feet long, making a pond 200 feet in length. There is at all times plenty of water in the stream to develop this power, and it is stated that the fall could easily be increased to 24 feet.

A short distance above the Nutty planing mill is the sawmill operated by J. H. Maddox, where the fall is 18 feet, about 10 horsepower being developed by a homemade wheel built like a turbine. The plant consists of a small sawmill, including planer, turning lathe, and a pair of corn stones. The dam is 60 feet long and $3\frac{1}{2}$ feet high, backing water to the tailrace of the mill above, a distance of about 100 yards. The race is of wood and is 96 feet long.

One hundred yards above the Maddox mill is the flouring mill of the Farmers' Milling Company, located in the village of Paperville. This is a 40-barrel roller flour mill operated by an 18-foot overshot wheel of $4\frac{1}{2}$ feet face, which is said to furnish 20 horsepower. The flow of the stream at the time of the visit in July was said to be sufficient to operate the mill only about half the time, but for nine months of the year the stream furnishes water sufficient to run the mill night and day. A gaging was made of the water in this flume.

The next mill is about one-fourth of a mile above Paperville and about $2\frac{1}{2}$ miles below Bristol. It is known as the Rutherford mill, and is a gristmill operating one pair of wheat stones. The dam is of wood, 8 feet high, and gives a fall of 11 feet at the mill, through a wooden race about 100 feet long. The power is developed by a 20-inch New American turbine yielding 15 horsepower. It is stated that there is generally sufficient water in the stream to operate this mill all of the time, but when visited in July the flow of the creek was insufficient to operate it more than a very small part of the time. The miller, who had known the stream many years, stated that it was at a lower stage than at any time within his recollection.

The total fall of the creek between Rutherford's mill and Nutty's woolen mill is said to be approximately 135 feet; by aneroid measurement it was determined to be 130 feet. The fall used by the several mills aggregates 121 feet, all within a distance of less than a mile.

THOMAS CREEK.

The next tributary, entering also from the north, is Thomas Creek. Its drainage basin is level to gently rolling, and is from 85 to 90 per cent cleared land, a very large proportion of which is grass covered. At the time of the July visit it was thought that the stream was carrying too little water to be measured with a current meter, but at the time of the September visit the creek was somewhat higher and was gaged a few hundred yards above its mouth. It was carrying 2.46 second-feet. The flood rise is about 5 feet. There is one small combined sawmill and gristmill on the stream, using a small amount of power, developed by an overshot wheel. Formerly there was a mill near the mouth of the creek, but it has been torn down.

RIDDLE AND JONAH CREEKS.

The next two tributaries entering from the south are known as Riddle Creek and Jonah Creek, respectively. These are two small streams of about the same size and having drainage basins of the same general character. Much of the timber has been cut from the area drained by them, and the proportion of cleared and cultivated land is about one-third of the whole. The forest growth, or more properly the undergrowth, on the remainder of the area is very sparse, owing to extensive lumbering operations. It is said that since the lumbering began the streams are much more flashy, falling much lower and rising higher and more rapidly, and that the floods are much more destructive than formerly. These streams attained their minimum stage of flow during the summer and fall of 1900. The average rise at the mouth of each is from 4 to 5 feet. Corn is the principal product of the basin, and no mines or minerals of any kind are known.

FISHDAM CREEK.

The next tributary, which enters the river from the east, at the head of the Horseshoe Bend, is Fishdam Creek. It drains an area entirely forest covered, excepting a few acres at its mouth. The immediate valley is very narrow and swampy and is covered with dense laurel thickets. The hills are steep and at the lower end of the valley are very high and mountainous. The country rock of the basin is slaty in character. The stream seems to have a large low-water flow, and is said to be less flashy than Jonah Creek or Riddle Creek, whose basins have been deforested, but active preparations are now being made to cut the timber in this area also. The Holston Valley Railroad is being graded along its course as rapidly as possible, and after that is completed the timber will rapidly disappear. Fishdam Creek, like all other streams in this section of country, reached its lowest stage during the summer and fall of 1900. During floods the rise at its mouth is about 4 feet above its average water level.

SHARP CREEK.

Sharp Creek also enters the river from the east. It is a small stream draining an inconsiderable area, the largest part of which is in forest, although there is considerable cleared land near the mouth of the stream, where the hillside slopes are gentle, ranging from 10 to 15 degrees. As the stream is ascended the hills are steeper and there is no cleared land. The cleared land in the basin amounts to about one-third of the area. On it fine vegetables and fruits can be grown, grapes thriving especially well. Much of the pine and poplar has been taken out of the forests, but the oak, beech, and chestnut remain. Considerable tan bark has been stripped, but very little has been taken out.

The slopes of the mountain sides are steep, being in some cases 60 degrees or more, and they are often covered with angular fragments of broken stone ranging in size from bits a few inches in diameter to blocks several feet across. The soil of the mountain slopes seems composed entirely of vegetable mold, which is mingled with these fragments. Near the tops of the mountains there is very little rock, the surface being covered with vegetable matter, black and moist, and the forest growth being very dense and luxuriant, composed for the most part of oak, with small quantities of chestnut, hemlock, and spruce. The stream is subject to fluctuations of about 6 feet.

The first mill on the creek is Lawson's mill, a small gristmill operating a single pair of stones by means of a small flutter wheel which yields an unknown amount of power. There is a fall of 14 feet available at this mill, but the quantity of water is very small. Moore & Graham's mill is a small sawmill near the headwaters of the creek. It uses about 14 horsepower and cuts about 500 feet of lumber a day.

Sharp Creek has a large fall and there are many sites where mills could be located.

SPRING CREEK.

The next important tributary is Spring Creek, which enters from the north, a short distance above the boundary line between Virginia and Tennessee. Its drainage basin possesses the same general characteristics as the other basins, consisting of broad, low, and rounded hills and ridges, with wide, flat spaces between, all the slopes being very gentle, and there being from 75 to 90 per cent of cleared land, the larger part of it in grass, hay, and grain, which are the chief agricultural products. In this basin limestone is the country rock and slate is seldom seen. The creek has periods of very low flow, and during floods it rises rapidly to a height of about 5 feet above its low-water level.

The first mill on the stream—Combes & Garrett's—is about a mile above the mouth. It is a gristmill containing two sets of buhrs, two stands of rolls, and a corn mill, the machinery requiring about 10 horsepower for its operation. The power is developed by a 16-foot overshot wheel with 42 inches face, which is said to yield 16 horsepower. The dam is 250 yards above the mill and is of stone, 7 feet high and about 100 feet long. By the use of a turbine 21 feet fall could be obtained at this place.

King's mill, the second mill on the stream, is 2 miles above its mouth. It is a gristmill operating three sets of buhrs driven by a 40-inch Leffel turbine working under a head of 10 feet and yielding an unknown amount of power. It is stated that 8 horsepower is sufficient for the operation of the machinery. The dam, which is at the mill, is of timber frames planked over on the upstream face, and is 10 feet high and 30 feet long, giving a pond 300 yards in length.

Hawkins's mill, the next mill above the King mill, is a sawmill having a capacity of about 2,000 feet a day, using an unascertained amount of power, which is developed by a 36-inch turbine working under a head of 12 feet. There is no race, the dam, which is of stone, 12 feet high and 35 feet long, being located at the mill. It is said that ordinarily there is sufficient water in the stream to operate this mill all of the time, but when it was visited in July the entire flow of the stream was leaking through the dam.

On the top of a hill by the roadside just before Hawkins's mill was reached three or four potholes were noticed which had been worn out in the solid limestone, the country rock over this part of the area. These holes were unmistakably due to the action of water flowing in a stream channel for a considerable period, and as they are more than 100 feet above the present level of the creek they would seem to indicate material changes in this country during very recent geologic times.

JACOBS CREEK.

The next tributary is Jacobs Creek, which flows in from the east and drains a large area of rolling country, slightly broken near the river but very rough and mountainous near the headwaters. The basin is largely wooded, in a very heavy forest growth, and probably less than 10 per cent of the land is cleared. During low water the stream falls to a very low stage, and during floods it rises about 5 feet at the mouth. So far as could be learned neither mineral nor lumber industries are carried on in this basin, nor are its waters used to operate any mills.

WOLF CREEK.

Wolf Creek, entering from the north, is the next tributary. It is about 10 miles long and drains a large area. The valley is wide and flat and is almost entirely cleared and grass covered. Limestone is the country rock, slate being seldom seen, though an occasional ledge of much jointed and laminated slate was noticed. The fall of this stream seems to differ greatly from that of other streams of the region, in that it consists of a succession of vertical plunges of from 1 to 6 feet, the intervening stretches being comparatively still and placid water. Along the upper part of the stream, near Vance's mill, the fall is very great, amounting to more than 50 feet in 1 mile, while above and below that point, where the creek flows through and between the Great Knobs, the fall is much less.

The largest fall on the creek is a few yards above its mouth, and is said to have been measured with an engineer's level and to be about 100 feet in 100 yards; the aneroid barometer, however, gave it somewhat less than that. This fall is the site of the first mill on the stream, known as the Falls mill, owned by Pitt & Nutty, of Stump, Va.

Formerly there was a fine mill here, but of late years it has been suffered to fall into disrepair. At the time it was visited in July, however, repairs were in progress, and it was stated that a roller flour mill of 40 barrels' capacity was to be installed at once. The log dam at the head of the falls is 8 feet high and 50 feet long. The race is about 100 feet long and gives a fall at the mill of 36 feet. The power is to be developed by a 12-inch double turbine, which will yield 35 horsepower under the head stated. It is claimed that this site will develop 280 horsepower the year round by using all of the fall, but there is some trouble from lack of water, which at times is held back by the mills upstream until late in the day.

Vance's mill, the next one on the creek, is about 2 miles south of Abingdon, at the upper end of the gorge referred to. It is a small sawmill and gristmill of two runs of stones, the sawmill and each pair of stones being operated by a separate overshot wheel about 16 feet in diameter. No estimate of the amount of power necessary for the operation of the machinery could be obtained. The dam is a timber structure 12 feet high and 100 feet long, and is very leaky. The race is a wooden flume about 150 feet long, giving a fall of 18 feet at the wheels. This power could be greatly increased by taking in a fall of about 6 feet just below the mill and using all of the water in two small turbines.

DENTON VALLEY CREEK.

The next tributary is Denton Valley Creek, one of the largest streams flowing into the South Fork. For the first 3 miles above its mouth there is a large proportion of cleared land in the basin, amounting to probably one-third, practically all of it grazing land. In even the cleared areas the hillside slopes are steep, ranging from 15 to 30 degrees, and show a great deal of exposed rock, everywhere a limestone. Farther upstream, however, the country becomes very rough, rugged, and mountainous, and is densely forested, with a soil that is seemingly very moist all of the time. As the creek is ascended the limestone of the lower part of the basin gives place to a slate, and near the top of the mountains the slate is replaced by a sandstone which on disintegrating becomes a fine, light-yellow to white sand. This stream falls very low and has a maximum rise of $4\frac{1}{2}$ to 5 feet, rising and falling rapidly, although less rapidly than others in the immediate vicinity.

There is but one small mill on the creek, and there is no information concerning it at hand. Near the mouth of the stream are the remains of an old bloomery furnace, seemingly out of operation for many years. As no ore was heard of in the immediate basin it must have been brought from the deposits in the Shady Valley, which can be reached from the head of the stream.

FIFTEENMILE CREEK.

Fifteenmile Creek, entering the river from the north, is the largest tributary. Its drainage basin seems entirely similar, especially as to soil, country rock, and topography, to the area drained by Wolf Creek. The fall occurs in the same succession of plunges and pools as noted on the latter stream, and like it there is at the mouth a very heavy fall in a short distance, in this case amounting to between 135 and 140 feet in about 1 mile. In this part of its course the creek has cut away a deep gorge, and all of the fall could be utilized with a comparatively small expenditure of money. The flow of the stream is ample to furnish a large amount of power from the fall. A short distance back from the stream the country is flat and has the same general characteristics as noted for the limestone areas.

There is but one mill on this stream. It is at the head of the fall mentioned and is known as the Parks mill, being a combined sawmill and gristmill. The latter operates two sets of stones, one for corn and one for wheat, the power for both being furnished by one wheel, a 16-foot overshot wheel of 5-foot face. The old jig sawmill is operated by a small flutter wheel. The dam is a timber-crib structure planked on the upstream side, and is 8 feet high and 50 feet long. The race is short, partly in excavation and partly a wooden flume. It is stated that the stream never falls so low as to make it necessary to use all of the water in the operation of the mill, and according to the best information obtainable it reached its minimum stage of flow during the season of 1900.

**TRIBUTARIES OF SOUTH FORK OF HOLSTON RIVER ABOVE
JUNCTION WITH THE MIDDLE FORK.**

DISCHARGE MEASUREMENTS.

All of the important tributaries of the South Fork below the junction were visited during the investigation, and measurements were made of most of them, the results of which are given in the following table, in order upstream:

Discharge measurements of tributaries of South Fork of Holston River above junction with the Middle Fork.

Date.	Stream.	Locality.	Hydrographer.	Gage height.	Discharge.
1900.				<i>Feet.</i>	<i>Sec.-ft.</i>
July 28	Beaverdam Creek.	Damascus, Va	E. W. Myers	11.36	189.00
Oct. 3	do	do	do	12.26	32.40
July 29	Whitetop Creek.	At mouth, Virginia	do	5.47	100.00
Oct. 2	do	do	do	5.72	34.30
July 29	Atcheson Creek	Near Head of Laurel, Tenn.	do	1.82	4.32
Do	Laurel Fork of Holston River.	One-half mile above Laurel Bloomery, Tenn.	do	2.06	23.00
Do	do	Near Laurel Bloomery, Tenn.	do	5.12	61.00
July 28	do	One-half mile below Damascus, Va.	L. V. Branch	3.56	351.00
Oct. 3	do	do	E. W. Myers	4.61	88.14

Discharge measurements of tributaries of South Fork of Holston River above junction with the Middle Fork—Continued.

Date.	Stream.	Locality.	Hydrographer.	Gage height.	Discharge.
				<i>Feet.</i>	<i>Sec.-ft.</i>
1900. July 28	Rush Creek	Ford 100 yards above mouth, Virginia.	L. V. Branch	3.63	4.20
Oct. 2	do	do	E. W. Myers		2.00
July 27	Mill Creek	One mile above mouth, Virginia.	L. V. Branch	4.32	18.00
Oct. 2	do	do	E. W. Myers	4.43	13.03
July 27	Grose Creek	At mouth, Virginia	L. V. Branch	3.88	2.00
Oct. 2	do	do		(*)	
July 27	St. Clair Creek	do	E. W. Myers	5.76	8.27
Oct. 2	do	do	do	5.94	2.00
July 27	Hogt rough Creek.	Lower ford of main road, Virginia.	do	0.87	9.00
Oct. 2	do	do	do		1.00
July 27	Pomer Creek	At mouth, Virginia	do	2.10	39.00
Oct. 1	do	do	do	2.29	5.00
July 27	Jim Scot Branch	do	do		4.12
Oct. 1	do	do	do		0.50

* Almost dry.

NOTE.—In making the measurements recorded in the above table bench marks were established and measurements were made, by means of a steel tape, of the distance from the bench mark to the surface of the water. An increase in the gage height, therefore, means a lowering of the water surface and a corresponding decrease in the discharge of the stream—the reverse of the results at the regular stations of the Survey, where gages are installed and where an increase in the gage height represents an increase in the discharge of the stream.

On the following pages are given descriptions of the drainage basins and water powers of the principal tributaries of the South Fork above the junction with the Middle Fork, in order upstream.

LAUREL FORK.

The first important tributary of the South Fork above the junction with the Middle Fork is the Laurel Fork, or Laurel Creek, as it is often called, which rises in the northwestern part of Johnson County, Tenn., and flowing in a general northerly and northwesterly direction empties into the South Fork about 4 miles above the junction with the Middle Fork, being joined in its course by two streams as large as itself, viz, Beaverdam and Whitetop creeks. It drains a rough, steep, and mountainous area containing a very small proportion of cleared land, which is confined to the small tracts lying along the stream below Damascus and to the broad meadows about the towns of Head of Laurel and Laurel Bloomery, but these are very inconsiderable in comparison with the total area drained.

Between the mouth of the creek and the first ford there is a fall of about 10 feet, and about 100 yards above this ford there is another fall of from 6 to 7 feet over rock ledges which cross the stream at right angles. Above this the average fall per mile is very large, and though it is well distributed there are a number of places where fine mill powers could be obtained by building dams; and as the banks are high and steep and the slope of the channel is great, no arable land would be flooded. As a rule the banks on the north are precipitous cliffs of limestone from 100 to 150 feet in height, while

on the south side the banks are lower and in places wide bottoms spread out.

There is a fall of about 50 feet between Damascus and the mouth of Whitetop Creek, a distance of about 2 miles. The valley along this stretch is quite narrow and the banks are high, there being only two or three strips of clearing, which lie well above the limits of high water and are of small area, from three-fourths of an acre to 1 acre each. The hills rise steeply from the river, and the opportunities for building high dams are numerous.

Above the mouth of Whitetop Creek the fall of the stream is very great, being between 265 and 270 feet between that point and the first ford below the town of Laurel Bloomery, a distance of about $4\frac{1}{2}$ miles, making the average fall about 60 feet to the mile. Along this portion of its course the stream falls continuously over ledges and boulders, and there is no stretch of still or smooth water. In places the fall is greatly concentrated. The valley is very narrow, and the hills rise almost perpendicularly from the stream to heights of from 200 to 300 feet. There is much white pine and spruce throughout this section, and there seems to be absolutely no cleared land upstream from the mouth of Whitetop Creek until near Laurel Bloomery. There is only one small tributary stream in this distance, but there are many springs, and the stream gains a large amount of water from them and from seepage between the rock layers. Near Laurel Bloomery the valley widens out and contains much cleared land, practically all of it in grass. The site of the only furnace is about a half mile from the lower end of the valley. No trace of it remains, however, except remnants of the log dam and some heaps of cinders.

Between Laurel Bloomery and the gap or divide separating the waters of the Laurel Fork from those draining into the Watauga, the general appearance of the valley is very like that of the lower part of the Holston Valley, consisting, as it does, of broad, low, and gently rolling swells, almost entirely cleared and grass covered, with herds of cattle feeding over them and with the general appearance of prosperity which marked the other area. The upward slope is gradual, and the whole character of the stream seems in every way different from that of the lower part of its course.

Although power in large amounts could be obtained almost anywhere on the Laurel Fork, very little use has been made of its waters. The first power used is at the mill of A. A. Mock, about $1\frac{1}{2}$ miles above the mouth of the stream. This is a combined sawmill, gristmill, roller mill, and flour mill. The buildings are old and greatly in need of repairs. The available fall is 10 feet, and the water is turned onto a 20-horsepower Leffel turbine, used in the operation of the flouring mill and the gristmill, while an old, homemade wheel operates the sawmill. The flour mill has a capacity of 30 barrels per day, the sawmill a capacity of less than 1,000 feet. The dam, which

is of logs, is about 200 yards above the mill and is 4 feet high and 150 feet across the top.

The first power development in the valley, near Laurel Bloomery, is the pipe factory, which uses a small amount developed by a 10-foot overshot wheel with 4 feet face. This factory manufactures pipe stocks from laurel burls. About 200 yards above this is a small gristmill with only one run of stones, using a fall of 10 feet. Above this gristmill there is no utilized power until the mouth of Gentry Creek is reached, where Robinson's mill, a small gristmill of one run of stones, is located, taking water from Gentry Creek and using a fall of about 10 feet and a very small amount of power. A short distance above this mill on Gentry Creek there is a similar mill on the Laurel Fork. As far as the mouth of Atcheson Creek the fall is small and there are no mills, the creek flowing placidly along between wide and fertile bottoms.

Limestone becomes less abundant as the creek is ascended, and much gneiss, quartz rock, and sandstone make their appearance, while occasionally a thin stratum of a species of conglomerate composed of rounded and water-worn pebbles firmly cemented together and lying conformably with the limestone is to be seen.

The Laurel Fork receives two large tributaries and a number of small ones. The first tributary of importance as the stream is ascended is Beaverdam Creek, which enters just below the village of Damascus.

Beaverdam Creek.—This stream rises in the curious elevated valley between the Holston and the Iron mountains which is known and famed throughout the country as the Shady Valley. Throughout the greater part of its length the stream is inaccessible, there being no roads traversing the area, which is very rough, rugged, and mountainous, and is entirely forest covered, except for the small area of cleared land in the Shady Valley. A railroad, however, is now being built along the creek to tap the forests of the Shady Valley, and the country will soon be opened for settlement and for lumbering.

There is only one mill on the stream, and this is located a few yards above its mouth, in the village of Damascus, and is known as Wright's mill. It is a small wood-working shop and corn and chop mill, requiring about $16\frac{1}{2}$ horsepower, which is developed by a 16-inch Little Giant turbine working under a head of 16 feet and using only a very small part of the water carried by the stream. The race is a wooden pipe 1,000 feet long, which follows the level of the stream. The dam is 1 foot high, barely sufficient to turn aside a small part of the water, and of course it gives no pond. At the time the stream was visited in October it was discharging 32.4 second-feet, and was said to be 6 or 8 inches above its extreme low-water mark. The flood rise at this point is about 4 feet.

Indications seem to point to the fact that the Shady Valley was at one time an old lake bed, or at any rate that still water had much

to do with its present formation, since in many places timber is found buried several feet below the surface of the ground. The valley floor is rather level, though seemingly higher in the middle than at the edges. The soil is deep, rich, and moist, being very swampy in places, owing to insufficient drainage. The forest growth is very luxuriant, chiefly white pine and spruce, though some chestnut and other trees are found, some of them of great size, being 100 feet to the first limb. It is stated that the timber in the valley will average 10,000 to 12,000 feet B. M. per acre, and that some tracts will run as high as 50,000 feet per acre. In the swampy areas the soil seems to be entirely a rich, black, vegetable mold, in many places very acid and requiring the application of lime before it can be cultivated with success. In the higher parts of the valley the soil is of a light-yellowish color, with some clay, and fine crops of corn and wheat are produced. The lower part of the valley is more broken and hilly than the upper part, and the proportion of cleared land is much less, diminishing to nothing between 2 and 3 miles below the town of Shady. The Empire Lumber Company is now constructing a large sawmill in this valley. All bricks necessary for their building operations have been burned from a fair quality of brick clay found on the spot.

Whitetop Creek.—This is the next tributary of the Laurel Fork, entering that stream about 2 miles above the mouth of Beaverdam Creek. It drains a very large area, which is entirely forested, the basin being covered with high and rugged mountains having steep and rocky slopes. The fall in the creek is said to be very great and to be much concentrated in places, making wild and picturesque scenery. There are no roads traversing the basin, with the exception of one leading to Whitetop Mountain, so that the country is inaccessible unless the creek be waded. At the time of the July visit the stream was carrying 100 second-feet of water and was said to be 5 or 6 inches above its low-water level. Its extreme flood rise is between 6 and 7 feet. The timber found in the basin includes all of the varieties usually found in the high mountains, and the country rock is reported to be a limestone over the lower part of the area, giving place to metamorphic rocks as the stream is ascended. Some of the higher mountains on the borders of this basin are said to be among the most picturesque in all the mountain region, Whitetop and the views obtainable from it being particularly beautiful. This mountain is a summer resort, being a favorite place for mountain parties. The construction of the railroad up the valleys of the Laurel Fork and Beaverdam Creek will in a measure open the valley of Whitetop Creek also, and will render practicable the development of many of the water powers along its line. This will probably be the result, the power being used in the operation of small flouring mills, which will thus be enabled to find a market for their products, or in wood-working establishments, for which this section offers a very fine field,

as material of the best quality exists in abundance on almost every mountain side. A beginning in this direction has been made by the establishment at Abingdon and at Laurel Bloomery of small mills for working the laurel burls into pipe shapes, from which so-called French briar pipes are manufactured. So far as could be ascertained there are no mining operations in this basin and no minerals occur in profitable quantities.

ROSENBAUMS CREEK.

Rosenbaums Creek, or, more properly, Rosenbaums Branch, is the next tributary of the South Fork. This is a small stream not more than 4 or 5 miles long, draining a narrow valley and discharging a quantity of water too small to be measured with a current meter, but which was estimated to be about 0.5 second-foot at the time of the visit in September. This is, however, not the discharge from the whole area, for as the stream was ascended the channel was found to be perfectly dry less than a mile above the mouth, though the stream was carrying an appreciable quantity of water about $1\frac{1}{2}$ miles above the mouth, the entire flow sinking into the earth. So far as seen the basin consists of rather low hills, grass covered, with very steep slopes, 40 degrees in some cases. The proportion of cleared land is large, being between two-thirds and three-fourths of the area, and is confined to a strip lying along both sides of the creek. Much of the area—probably more than one-half—is in grass, the remainder being about equally divided between corn and wheat. The country rock seems invariably a limestone, and the soil is light and porous. A small amount of timber is being cut on the hills rimming the basin, being worked by a number of small mills on the spot.

WIDNER CREEK.

Widner Creek joins the South Fork about 2 miles above the mouth of Rosenbaums Creek, and though the area drained by it seems to be slightly larger than that drained by the latter creek, and a larger proportion of the basin is said to be forested, the discharge was very much less, being inappreciable at the mouth, the only place where the stream could be seen.

RUSH CREEK.

Rush Creek, the next tributary, enters the South Fork about 2 miles south of the village of Friendship, and is a slightly larger stream than either of the last two described. The area drained is very rough and mountainous, and is about two-thirds forest covered. At the time it was visited, on October 2, it was carrying 2 second-feet, and was said to be at its lowest known stage. Its flood stage is about 3 feet higher.

MILL CREEK.

Mill Creek, the largest and most important tributary entering the South Fork along this part of its course, was gaged about a mile above its mouth, the only place where the stream could be reached, and on July 27 was carrying 18 second-feet and on the 2d of October 13.03 second-feet. The drainage basin is inaccessible and was not visited. Residents of the locality state that with the exception of a narrow strip along the creek not far from the river the basin is very rough, rugged, and steep, and is entirely forest covered. Much less than one-third of the total area is cleared land. There are a number of large springs in the basin. The stream was stated to be at its extreme low-water flow at the time of the October visit, when it was carrying 13.03 second-feet. The average flood rise is about 4 feet, although in some cases it has been as great as 5 and 6 feet.

GROSE CREEK.

Grose Creek is a small branch which was carrying 2 second-feet on July 27, but was almost dry at the time of the October visit. Its drainage basin seems to differ in no way from those of the streams entering below it.

ST. CLAIR CREEK.

St. Clair Creek drains perhaps a larger proportion of cleared land than any other stream in this vicinity, all the land along it being cleared to the foot of the mountains, but probably four-fifths of the entire basin is in forest. This stream was measured near its mouth at time of extreme low water, on October 2, and was carrying 2 second-feet. The rise during floods is about 4 feet.

Considering as a whole the area drained by Widner, Rush, Grose, and St. Clair creeks, it is very rough and mountainous, with steep, forested slopes, the small proportion of arable land, which amounts to less than one-fifth of the area, being confined to narrow strips bordering the creeks and immediately along the river.

WEDSTONE CREEK.

Wedstone Creek enters the river from the south, at Holstein Mills, and at the time it was visited it was carrying a quantity of water too small to even be estimated. Its extreme flood height is about 3 feet above its low-water stage. Its drainage area is largely cleared land, the forested portion being less than that of any of the other basins mentioned and estimated to be about one-third.

HOGTROUGH CREEK.

Hogtrough Creek, the next tributary above, was also too small to measure at the time of the September visit, carrying about 0.5 second-foot (estimated), which is probably the minimum flow. The flood

height is about 3 feet. The area drained is for the most part rough and steep, and the proportion of cleared land is very small, being confined entirely, so far as could be ascertained, to the first $2\frac{1}{2}$ or 3 miles above its mouth and to tracts lying within 200 or 300 yards of the stream.

There are two small mills on the creek, the first one about 100 yards above its mouth, being a small sawmill and gristmill known as Pierce's mill. The power is obtained from a 16-foot overshot wheel with 4 feet face. The mill operates only one pair of stones, grinding for toll only, and saws an extremely small amount of lumber. About a mile above the mouth of the creek is a small mill operating one pair of stones by a 16-foot overshot wheel, but the name of the owner was not ascertained, nor any data regarding the power developed.

POMER CREEK.

Pomer Creek is the largest tributary to the South Fork in this part of its course. It drains an area rougher and steeper than any of those yet described, and one containing a smaller proportion of cleared land. The cleared area is confined to a narrow strip along the stream close to its mouth. There are no mills on the creek, so far as could be ascertained, though about a mile above its mouth there are evidences of a mill, which was probably washed away by one of the freshets to which the stream is subject. This creek reached its minimum flow in the fall of 1900. It was measured on October 1, when the discharge was 5 second-feet. The flood rise is about 4 feet. The amount of water carried during floods is very great.

This was the last tributary investigated, as the river was not followed much above the Rye Valley, and was too small at this point to be of value for water-power purposes. There is but little scenery worthy the name to be found over the larger part of this area, most of the country presenting a very quiet, pastoral type of beauty.

MIDDLE FORK OF HOLSTON RIVER.

PHYSICAL FEATURES.

The Middle Fork rises a little to the south of the village of Old Mount Airy, Va., on the western slope of the Blue Ridge, in the valley between Walker Mountain on the north and the Brushy Mountains on the south, and flows in a direction generally parallel to the course of the South Fork until a few miles above the junction, where it turns to the southwest. Below the junction the stream continues its general southwesterly course, and after being joined by the Watauga it unites with the North Fork of Holston River, near the town of Kingsport, Tenn., forming Holston River, which is in turn joined by the Nolichucky and the French Broad and finally unites its waters with those of the Little Tennessee, forming a system which drains southeastern Virginia, western North Carolina (excepting a small portion the waters from which flow into the New river system),

eastern Tennessee, northern Georgia, and northern Alabama. That part of the area lying in the basin of the South Fork is mapped on the Roan Mountain, Bristol, Abingdon, and Wytheville atlas sheets of the Geological Survey. The area drained by the Middle Fork lies mostly to the north of the river, the distance from the summit of the ridge dividing its watershed from that of the South Fork to the stream being too small to admit of the formation of streams of considerable size. The general character of the country is similar to that of the area drained by the South Fork below the junction, the topography consisting of small and rounded hills and ridges, grass covered to the top, with very gentle slopes and with low divides between the small creek watersheds. By far the larger part of the area is cleared land, the woodland amounting to probably less than 10 per cent for that part of the basin lying between the junction and the mouth of Bear Creek. Above that point the valley becomes very narrow, being constricted between the slopes of the two peaks forming the Brushy Mountains, which are in a large measure wooded. Throughout the remainder of the basin the wooded areas are mostly in the form of small groves or tracts of a few acres. The soil is seemingly very fertile and is light and porous, though some areas of clay were found. Limestone is the country rock, and the bed of the river is also in that stone. The area drained by the Middle Fork constitutes the finest and most prosperous farming and stock-raising country seen during the whole investigation, and the lands are held at a high valuation.

DISCHARGE MEASUREMENTS.

During the investigation a number of measurements were made of the flow of this stream and of its principal tributaries. The measurements made on the Middle Fork are given in the following table, those made on its tributaries are given in the table on page 73.

Discharge measurements of Middle Fork of Holston River.

Date.	Locality.	Hydrographer.	Gage height.	Discharge.
1900.			<i>Feet.</i>	<i>Sec.-ft.</i>
July 25	Sevenmile Ford, Va	L. V. Branch	13.00	71.23
Do...	Above mouth of Bear Creek, Virginia	do	6.23	18.00
Oct. 1	do	do	7.69	11.00
July 24	Five miles above mouth, Virginia	E. W. Myers	5.96	172.00
Sept. 28	do	do	6.21	100.00

NOTE.—In making the measurements recorded in the above table bench marks were established and measurements were made, by means of a steel tape, of the distance from the bench mark to the surface of the water. An increase in the gage height, therefore, means a lowering of the water surface and a corresponding decrease in the discharge of the stream, the reverse of the results at the regular stations of the Survey, where gages are installed and where an increase in the gage height represents an increase in the discharge of the stream.

WATER POWERS.

For 100 yards above the junction with the South Fork there is a fall of about 8 feet in 100 yards, as near as could be ascertained, over a very rough and rocky bed formed by ledges of limestone crossing the

river at right angles. High and steep bluffs rise from the water's edge on both sides of the stream, and from them large quantities of limestone could be quarried. A railroad crosses the stream just below the shoals, and would afford ample transportation facilities. This locality would repay an investigation by anyone desiring power in this section.

About $2\frac{1}{2}$ miles above the mouth of the stream there is a fall known as Big Shoals, where the river is divided by several islands, the largest of which is about an eighth of a mile long. In one-fourth of a mile, as near as could be estimated, there is a fall of 10 feet, determined by hand level and aneroid, and near the head of the shoals there is a fall of about 4 feet in a distance of 100 feet, and an abrupt descent of about 3 feet at the foot over a rock ledge crossing the stream at right angles. On the south side of the river broad bottoms extend the length of the shoals, but on the north side the banks are high and bluff. The country rock close to the river seems to be slate of two varieties, one hard and black, the other soft and either yellow or gray. Limestone occurs in small quantities close to the stream, but it forms the predominating rock of the uplands.

From the mouth of Hogthief Creek to De Busk's mill the river is a placid stream, with very little fall. The rock is a limestone which quarries well, and almost all of the country, which is very rolling, seems to be cleared. At De Busk's mill there is no race, a wooden flume taking the water from the forebay to the wheels. The dam is a timber structure planked on the upstream face, 10 feet high and 168 feet long, backing the water about 2 miles. The mill is a sawmill, but it also contains wood-working machinery. It is operated by a 36-inch turbine rated at 30 horsepower under $9\frac{1}{2}$ feet head, and has a capacity of 5,000 feet of lumber per day. At this site there is also a wheat mill with a capacity of 30 barrels per day, consisting of three double stands of rolls operated by a 20-inch Success turbine rated at 25 horsepower. The corn and feed mill is operated by a homemade wheel yielding about 4 horsepower. Sometimes during very dry seasons when all of the machinery of the mill is in operation at the same time the whole flow of the stream is required, as the dam is somewhat leaky, and at times the pond has been drawn down 1 foot during a day's run.

Above the De Busk mill and as far up the stream as Chilhowie there is very little fall in the river, and what there is is very well distributed, there being no noticeable concentration at any place. There are localities, however, where dams from 10 to 15 feet high could be built, but in every case the fall obtained would be that due to the dam, and the flooding of valuable lands above would prohibit the construction. The bottoms are very broad and lie only a few feet above the level of the river. The river receives practically no drainage throughout this part of its course, one stream only, Huttons Branch, being large enough to gage. The country rock is a limestone, and the land is practically all cleared and is given over to stock raising and to grain.

Above Chilhowie and as far as Sevenmile Ford there is no concentration of fall in the stream, and the country preserves the same general character, except that the bottoms begin to grow narrower and the hills to close in on the river and to rise higher and more sharply, the country presenting a much more broken appearance. The area is not so largely cleared, there being probably 25 per cent of woodland in this section. The stream has an extreme rise of 12 feet in this part of its course. At present there is no mineral industry hereabouts, though several years ago much baryta was mined, but practically all has been taken out that can be worked at a profit.

Glenn's mill is the first mill on the river above the De Busk mill. It is just above the mouth of Byars Creek, and is a combined gristmill and sawmill having a capacity of 40 barrels of flour per twenty-four hours, and, with three choppers, requiring about 46 horsepower. The total power development here is 64 horsepower. The wheels are homemade, center discharge, built on the turbine plan, and of 20, 16, 10, and 6 horsepower, respectively. The sawmill contains one sash saw requiring for its operation about 12 horsepower. The dam is of timber frames planked over, and is $11\frac{1}{2}$ feet high and 120 feet long, giving a working head of 11 feet at the mill and backing water about three-fourths of a mile. It is stated that there is always sufficient water to operate all of the machinery in this mill at the same time, though the dam is somewhat leaky.

The next power on the stream is about one-fourth of a mile below the town of Marion and is owned by Messrs. Look & Lincoln, who state that a fall of 10 feet can be obtained by building a dam of that height, and that no arable land would be flooded.

Look & Lincoln's mill, the next power above, is in the lower end of the town of Marion. Wagons, plow handles, and wagon materials are manufactured. There are two dams, the upper one of stone for half its length and of wood for the remainder, $9\frac{1}{2}$ feet high and 110 feet long, the water being turned directly into a 33-inch Success turbine developing about 30 horsepower. It is estimated that with this fall from 40 to 45 horsepower can be obtained the year round. Just below this dam the river makes a very abrupt bend, and about 150 yards below the upper dam, if the course of the river be followed, or 40 yards in a straight line, is the lower dam, belonging to the same firm. This dam is 8 feet high and 100 feet long, made of timber frames planked over, and backs the water to the foot of the upper dam. The water is led direct to a 36-inch turbine yielding about 20 horsepower, which is used occasionally to operate two sets of corn stones and a turning lathe. A steam engine of 100 horsepower is also used in the wagon-material department. The whole mill has a capacity of about 300 farm wagons annually and about 2,000 pairs of plow handles.

In the upper end of the town of Marion is Hull & Staley's mill, which has a capacity of 75 barrels of flour per day. The dam is one-fourth of a mile above the mill, and is of timber frames planked over.

It is 12 feet high and gives a head of 20 feet at the mill. There are two turbines, one a 30½-inch Leffel developing 32 horsepower, the other a 24-inch Success wheel developing 18 horsepower, and it is said that in seasons of low water the entire flow of the stream is necessary to operate the larger wheel.

About 3 miles above Marion is the Mount Carmel mill, a flouring mill with a capacity of 50 barrels per day, using about 32 horsepower, which is developed by two 30½-inch Leffel turbines working under a head of 9 feet. There is no race, the mill being built at the dam, which is new, of timber frames planked over, 9 feet high and 125 feet long, backing the water about 400 yards. The miller estimates that in the driest seasons there is in the stream only water sufficient to develop 16 horsepower with this head. He also stated that a portion of the water carried by the stream sinks into its bed between this mill and the town of Marion, but no evidence of this was seen.

There are no other mills or mill sites between the Mount Carmel mill and the mouth of Bear Creek, although the fall is considerable, and from the configuration of the country it seems probable that at a number of localities small amounts of power could be developed. The north side of the river is very steep and bluff, and on the south side the bottoms are higher above the river level than at any other place along the stream. Considerable limestone has been quarried in this vicinity, the greater part of it going to the alkali works at Saltville, Va.

TRIBUTARIES OF MIDDLE FORK OF HOLSTON RIVER.

DISCHARGE MEASUREMENTS.

During the investigation the following measurements were made of the important tributaries of the Middle Fork:

Discharge measurements of tributaries of Middle Fork of Holston River.

Date.	Stream.	Locality.	Hydrographer.	Gage height.	Discharge.
1900.				<i>Feet.</i>	<i>Sec.-ft.</i>
July 24	Hogthief Creek..	One-half mile above mouth, Virginia.	L. V. Branch	5.00	5.00
Sept. 29	do	do	E. W. Myers		5.00
Do ..	Cedar Creek	At mouth, Virginia	do		3.42
Do ..	Halls Creek	do	do	1.73	17.36
July 23	Huttons Branch	do	L. V. Branch	4.45	5.00
Sept. 29	do	do	E. W. Myers	4.43	5.00
July 25	Walker Creek	50 yards above mouth, Virginia	do	4.90	3.00
Sept. 29	do	do	do	4.89	9.00
July 25	Byars Creek	At mouth, Virginia	L. V. Branch	1.52	4.00
Sept. 29	do	do	E. W. Myers	1.58	2.24
July 25	Hungry Mother Creek.	Ford of main road from Marion, Va.	L. V. Branch	1.18	2.45
Oct. 1	do	do	E. W. Myers	1.17	2.36
July 25	Staleys Creek	Marion, Va	L. V. Branch	9.26	14.32
Do ..	Bear Creek	At mouth, Virginia	do	6.99	2.01
Oct. 1	do	do	E. W. Myers	6.90	3.00

NOTE.—In making the measurements recorded in the above table bench marks were established and measurements made, by means of a steel tape, of the distance from the bench mark to the surface of the water. An increase in the gage height, therefore, means a lowering of the water surface and a corresponding decrease in the discharge of the stream, the reverse of the results at the regular stations of the Survey, where gages are installed and where an increase in the gage height represents an increase in the discharge of the stream.

Descriptions of the drainage basins and water powers of these tributary streams are given on the following pages.

HOGTHIEF CREEK.

The first tributary of the Middle Fork of sufficient importance to deserve mention is Hogthief or Sevenmile Creek, which enters the river from the north, at Moab, Va., and has a reported length of about 7 miles, although as measured on the map it is only about 4 miles long. The greater part of its drainage basin is cleared, the woodland amounting to probably not more than 5 per cent of the area. About half of the cleared land is in pasture, the remainder being about equally divided between corn and wheat. The whole basin is either flat or gently rolling, though it contains a few small hills, some of which are wooded to the top, but the hillside slopes are all very gentle. Limestone is the country rock of the area. When the stream was visited (first on July 24 and again on September 29) it was, according to all obtainable information, lower than ever before known. On both occasions it was discharging 5 second-feet. It is stated that the maximum rise is about 4 feet. This stream is now much more flashy in nature than it was several years ago, due no doubt to the deforestation of its headwaters which has taken place within the last few years. Not only do the floods rise with greater rapidity and to a greater height than formerly, but during the dry seasons the creek falls to much lower stages, despite the fact that it is fed by many large springs.

The first mill on the stream is Kendrick's mill, located about 100 yards above its mouth. This is a gristmill of two runs of stones, operated by a turbine 12 inches in diameter, which develops 20 horsepower under a head of 27 feet, though it is probable that 10 horsepower will operate all of the machinery in the mill. The dam is about 100 feet above the mill and is about 5 feet high and 25 feet long, built of timber frames planked over, and gives a very small pond. According to the statement of the miller the stream was never too low to run the mill until 1899, but it has been so, except at intervals, since that time, and he attributes it to the cutting away of the timber from the headwaters.

CEDAR CREEK.

The next tributary of the Middle Fork is Cedar Creek, which enters the river from the north, about 3 miles above the mouth of Hogthief Creek, which it seems to resemble in every respect. Practically all of the area drained by Cedar Creek is cleared land, which is used almost exclusively for grazing purposes. The meadows are broad and fertile, and the grass-covered uplands are nearly level. There are a few small hills, but they have very gentle slopes. It is possible that this stream may fall about one-tenth of a foot lower than its stage at the time it was visited (September 29), when it was discharging 3.42 second-feet. Its maximum rise is about 3 feet above its low-water mark.

HALLS CREEK.

Halls Creek, which enters the river a short distance below De Busk's mill, is a slightly larger stream than either Hogthief Creek or Cedar Creek, but the distinguishing characteristics of its drainage basin seem similar in every respect to those noted for the other creeks. It falls between 2 and 3 inches below its level at the time it was visited (September 29), when it was discharging 17.36 second-feet. During floods it rises between 3 and 4 feet.

HUTTONS BRANCH.

The next tributary is Huttons Branch, locally and more properly known as Huttons Creek. This stream rises on the southern slopes of Walker Mountain and drains a very small area of wooded land. The rest of the basin is cleared and is used almost exclusively for grazing, being quite level, with very broad bottoms and small, gentle hills. This stream was visited on July 23 and on September 29, and at both times was carrying 5 second-feet. Its high-water rise is 3 feet. There is one mill on the creek, operating a single pair of stones by means of a 16-foot overshot wheel and using a very small amount of power. The creek forks just below the site of the mill, the forks being at an angle of nearly 180 degrees, and the water from both branches is brought to the mill through a long wooden flume.

CHILHOWIE BRANCH AND CARLOCKS CREEK.

These are the only other streams in this section carrying an appreciable amount of water, and their discharge was much too small to admit of measurement.

WALKER CREEK.

Walker Creek, draining the southern slopes of Walker Mountain, is the next tributary of the Middle Fork. The upper part of its basin is rough and steep and is practically all in woodland, but immediately along the forks there are considerable areas of cleared land, and below them practically all of the basin is cleared. Over this lower part the topography is similar to that noted for the streams lying farther down in the drainage basin of the main stream, except that the hill-side slopes are somewhat steeper and the hills a little less rounded. The creek is said to have attained its minimum stage of flow during the summer and fall of 1900. Its flood rise is about 4 feet. There are very valuable and extensive deposits of gypsum in this basin, but they have been very little or not at all worked.

BYARS CREEK.

This creek enters the Middle Fork from the south, about 4 miles below the town of Marion, Va., and is the first important tributary

rising in the area between the Middle and South forks. Considerable of the land in its basin is cleared and under cultivation or in grass. It is rather smooth and level, all of the slopes being gentle. Limestone is the country rock, and it has been quarried in large amounts for use in the alkali works at Saltville. During floods the creek rises about 3 feet at its mouth.

HUNGRY MOTHER CREEK.

The next tributary is Hungry Mother Creek, on the southern slopes of Walker Mountain. The upper part of its basin is a very rough and rugged country of extremely steep slopes, containing a small proportion of cleared land. In the lower part of the basin the country is much more broken than that of the basin of any tributary of the Middle Fork yet described, the hills rising sharply from the stream to considerable heights, and the uplands, which downstream were a plain, consisting of small and rugged hills, seemingly not more than half cleared. In this part of its course the valley of the creek is very narrow. Most of the cleared land is in grass, the remainder being cultivated in wheat; and although much of the area near the mouth is still in woodland, it seems probable that these areas are too small to have very great effect on the run-off. The soil seems shallow, and there is much exposed rock over the basin, all of it seemingly a limestone formation. The floods on this stream are violent, the creek rising 5 feet in a very short time, but the periods of high water are of short duration, owing to the great slope of the stream channel and the steepness of the hillsides over the basin.

STALEYS CREEK.

Staleys Creek, entering the river from the south, within the limits of the town of Marion, Va., is the next tributary. The valley of this stream so far as seen was very largely cleared, probably 50 per cent or more. The lower part of the basin is rolling and grass covered, but the upper part consists of the northern and eastern slopes of the Pond and the Brushy mountains, and is rough, broken, and mountainous, the slopes being very steep and forest covered. The lower part of the basin is in a limestone formation, but the slopes of the mountains are of sandstone. About 4 miles from Marion, in the valley of this stream, is an iron mine owned by Mr. J. L. Woodruff, of Marion, from which about 100 tons of ore are shipped daily to the furnace at Pulaski, Tenn.

The fall of the stream is considerable and it is more largely used for power purposes than any stream of its size in the region. The first fall is known as the Old Foundry site. A fall of 17 feet can be obtained at this place, yielding about 20 horsepower. The site is now unoccupied, but a small wagon factory is to be built at an early date.

About one-fourth of a mile above the Old Foundry site and practically one-fourth of a mile above the mouth of the creek is Seaver's planing mill, where the fall is 18 feet, and it is said that 18 horsepower is developed by one 18-inch Success turbine. The race is a plank flume 1,400 feet long, and there is practically no dam, only a slight obstruction, just sufficient to turn aside the water of the creek. The mill contains wood-working machinery and a gristmill, and it is said that the stream does not at all times furnish power sufficient to develop the horsepower stated, occasionally falling so low as to yield only about 9 horsepower with 18-foot fall.

Atkins Brothers' mill is 4 miles above the Seaver mill and manufactures spokes, hubs, pick handles, etc., and saws walnut timber for export. It uses about 18 horsepower, developed by an 18-inch Success turbine working under a head of 18 feet. There is a very slight dam, barely sufficient to turn the water aside. The water is led to the mill by a plank flume 200 feet long. This is the last mill on the creek.

BEAR CREEK.

Bear Creek, which enters the river from the north about 5 miles above Marion, Va., drains a part of the southern slopes of Walker Mountain and the northern slopes of the Brushy Mountains. The whole area is extremely rough and mountainous. Probably less than one-third of it is cleared land, the cleared areas being confined to the comparatively level land immediately along the stream and to some of the lower and more gentle slopes. The stream probably never falls lower than the point reached during July and August, 1900, when it was carrying about 2 second-feet. During floods it rises about 4 feet at the mouth. Some timber has been cut in the valley, and considerable quantities of tan bark are stripped and hauled to the railroad at Marion. There are no mills on this stream.

WATAUGA RIVER.

PHYSICAL FEATURES.

Watauga River rises on the northern and eastern slopes of Grandfather Mountain, on the southern boundary of Watauga County, N. C., and after flowing about 6 miles in a northeasterly direction is joined by Boone Fork, a stream which rises on the eastern slope of Grandfather Mountain and flows first due east about 4 miles and then to the north about 4 miles, or to its junction with the Watauga. At the junction the river changes its course to the northwest, and with many bends, rapids, and falls flows through Watauga County, N. C., and Johnson and Carter counties, Tenn., uniting its waters with those of the South Fork of Holston River about 9 miles northwest of Johnson City. In its course it is joined by many tributaries. It drains an extensive area, a large part of which lies in the

high mountains. The basin to the west of Carter, Tenn., was not examined, being well out of the mountains and of the same general character as the valley of Holston River already described. For convenience the basin has been divided into three parts, which are differentiated by very well marked physical characteristics. The divisions are: (1) The area lying to the west of the Iron Mountains on the north side of the river; (2) the area lying to the east of the Iron Mountains; and (3) the area lying to the west of the Iron Mountains on the south side of the river.

AREA LYING TO THE WEST OF THE IRON MOUNTAINS ON THE SOUTH SIDE OF THE RIVER.

This portion of the drainage basin of Watauga River comprises the areas drained by Gap Creek, Powder Branch, Buffalo Creek, Sinking Creek, and Brush Creek and is some distance from the mountains. As a consequence it is much less rugged than the country farther to the east, is better adapted to agriculture, and a great part of the land is cleared, hay being the principal product, though much corn and wheat are grown. Most of the area drained by these streams is either level or very gently rolling, and over the greater part of it probably about 90 per cent of the land is cleared, the woodland being confined to the tops of some of the higher hills and to small and isolated areas on the lower but less fertile tracts. Of the total area drained by these streams probably more than 75 per cent is cleared. The soil is deep and fertile and the country rock is without exception a limestone.

One of the peculiar features of this area is the large number of small closed drainage basins, or sinks, which have been noted in other watersheds of the region and which here occur in the nearly level uplands dividing the basins of the various small creeks. These sinks are particularly noticeable for their size and number near Milligan, Tenn., at which place occur the largest seen during the whole investigation, one of them covering an area estimated at 10 acres and having a large pool of water in its bottom. This locality is the only one, however, over the whole area drained by Watauga River in which these basins occur.

AREA LYING TO THE WEST OF THE IRON MOUNTAINS ON THE NORTH SIDE OF THE RIVER.

This portion of the basin includes the valley of Lick Creek, the areas drained by several small branches, the large valley drained by Stony Creek, and a part of the high and rugged area covered by the Holston Mountains. The latter, however, from its character more properly belongs to the area lying to the east of the Iron Mountains.

For perhaps a half mile or a little more to the north of the river, near Carter, the country is very hilly and rough, with steep slopes, and is largely wooded. It changes gradually as the level of the

uplands is reached and becomes gently rolling, being composed of large and broad swells or ridges and low, flattened hills rising from 25 to 30 feet above the level of the valleys between them, the valleys being generally broad areas of level land. The hillside slopes are very gentle, ranging from 5 to 10 degrees. About 75 per cent of the area appears to be cleared, about half of the cleared land being grass covered.

Limestone is the country rock, as on the south side of the river, but very little is seen exposed. The soil is deep and fertile, that in the immediate valleys of the creeks being largely alluvial, while on the uplands it is gray or yellow in color and loose and porous in character.

The forest growth, which is pine, oak, and chestnut, is in small areas, which as a rule are too widely separated to have much effect on the run-off.

The country immediately along the river from Carter to the town of Watauga Valley is much broken by a number of large hills, which are much steeper than those heretofore observed, but just above the latter place these recede from the river, leaving the general appearance of the topography similar to that noted on the south side of the stream, though a little more broken and rough. The hills are the outliers of the Holston Mountains, and are covered with a dense forest growth.

Near Elizabethton the bottom lands are very broad and fertile, extending up the river as far as the mouth of Stony Creek. The valley of the latter stream is of considerable width. Immediately along the creek and on the first bench or terrace the cleared land forms a large portion of the area, but with this exception the basin is in forest. The cleared land is said to amount to from 10 to 12½ per cent of the whole, this being all that is fit for cultivation, on account of the steepness of the slopes, the mountains rising very sharply from the valleys. They all are heavily timbered, little lumbering having been done in this area.

AREA LYING TO THE EAST OF THE IRON MOUNTAINS.

This part of the drainage basin of Watauga River differs very greatly from the areas just described, being rough, rugged, steep, and mountainous, containing a very small proportion of cleared and cultivated or cultivable land, being largely covered with the original forest growth, which is rank, dense, and luxuriant.

As the river is ascended the limestone, which was the country rock over the areas just described, gives place to slates, shales, schists, and sandstones, and these in turn to granites and gneisses, which form the country rocks over all of the basin in North Carolina. Away from the river the land seems to be about one-fourth cleared, but instead of the deep and fertile surface covering seen before the soil is shallow and in many places is full of rock fragments, often angular, sometimes rounded as if waterworn, and in many places a stratum of these

fragments 2 or 3 feet beneath the surface is seen exposed in the banks by the roadsides.

Toward the North Carolina line the amount of cleared land diminishes greatly, the mountains rising too steeply from the water's edge to admit of clearing. As the river is ascended the valley narrows and the mountains rise to greater heights, often showing precipitous walls of bare rock several hundred feet high, forming a chasm known as the gorge of the Watauga. An occasional small clearing may be found on the slopes back from the river, where the country is less rugged, and on these settlers try to wring a scanty subsistence from the stony soil; but as a rule the mountains are forested to the top, though occasionally an undue amount of exposed rock on the slopes renders the growth sparse and stunted.

Within the gorge of the Watauga there is no room for a road and barely space enough for the stream. The channel is very rough and broken by many rapids and sudden falls, and the water rushes along with great velocity. In the 8 miles through which the gorge may be said to extend the average fall is about 65 feet to the mile, and in many places it is much more concentrated, one notable locality being near the State line, where there is a straight plunge of 10 or 12 feet, known as the Falls of the Watauga.

Upstream from the gorge the mountains rise to less heights, the valley broadens slightly, and the uplands back from the river are suitable for agriculture on a small scale. They are partially cleared and cultivated in grass or grain in the places where the hillside slopes are not greater than 20 or 30 degrees. The hills do not recede far enough to permit the formation of bottoms until the broad strip of level land known as Valle Cruces is reached. A short distance above this the gorge is redeveloped, though in a lesser degree, and there is very little cleared land directly along the river until Shulls Mill is reached. There are small areas of cleared land up some of the tributaries, however, also along the river between Shulls Mill and Foscoe, so that it is estimated that of the total area drained by the river above the North Carolina line about one-third is cleared land; but after an inspection of the basin this estimate seems too great. Above Shulls Mill the Watauga has a length of from 5 to 6 miles, measured in a straight line, and drains an area of which a large part is well suited to agriculture, being in the form of broad and fertile bottoms and terrace lands lying close to the stream. About 4 miles above the mouth of the Boone Fork, however, the slopes of Grandfather Mountain on the north and of Hanging Rock on the south close in on the river and the amount of arable land becomes very small, the cleared land being about one-fourth or one-fifth of the whole area above the junction of the Boone Fork. The soil of the bottoms is deep and fertile, being largely a black alluvium, but that of the hillsides is often shallow and full of angular fragments of broken stone, and is not very productive.

The portion of the basin in North Carolina lies in Watauga County, which occupies the entire breadth of the very elevated mountain plateau between the Blue Ridge and the Unaka mountains. It is traversed in a northerly direction by two massive cross chains connecting these two great ranges, viz, the Rich Mountains and the chain of which Grandfather Mountain may be taken as the starting point and Hanging Rock and the Beech Mountains as the prominent peaks, the basin of the Watauga lying to the west of the Rich Mountains. The surface of the whole country is very rough and rugged and has an average elevation of about 5,000 feet above sea level. The stream valleys are as a rule very narrow, but at intervals there are considerable stretches of bottom lands. The soil is generally a stiff gray or yellow loam, producing grains and grasses in abundance. Cattle raising is an important industry. Along the headwaters of the stream there is much alluvial soil in the creek bottoms and a great deal of vegetable mold on the mountain slopes, while on Banner Elk Creek and Elk Creek the bottoms assume the form of peaty bogs, which are very deep and retain the water draining into them from the mountain slopes for a long time, feeding it out to the streams gradually.

SCENERY.

All of the area drained by the Watauga in North Carolina lies in the high mountains, and the scenery is wild and picturesque, the exact opposite of that along the lower part of the stream or on the Holston, which is quiet and pastoral. Many beautiful mountain views are to be obtained, with quick-changing cloud shadows and with wisps of filmy clouds clinging about the summits, but the valleys are so narrow and so tortuous that it is seldom a view can be obtained from a sufficient distance to give its full beauty, although there are places near the gaps and on the divides where may be seen views approaching in grandeur any that the mountains afford.

The rugged beauty of the whole area finds its culmination in the massive bulk of Grandfather Mountain, which rises to a height of 5,964 feet, far above any peak in the vicinity, and is probably the most massive, wild, and rugged of the peaks of the Southern Appalachians. Though by no means the highest peak in the range, it so towers above its surroundings that one of the most extensive views in North Carolina can be obtained from its summit. From certain directions and in clear weather the summit of this mountain is seen to form the profile of an old man—hence the name—but this is seldom visible, for this grandfather of mountains keeps his face almost perpetually veiled in the clouds.

RAINFALL.

Like all other drainage basins throughout this region, the basin of the Watauga is subject to a very heavy annual rainfall, being greater

near the headwaters, where Grandfather Mountain causes an almost constant precipitation. This rainfall at times comes in the form of violent rain storms, but these are infrequent, the precipitation being well distributed throughout the year, though the summer rainfall is the greatest in amount. At times the heavy rains are long continued, lasting a week or more, and the streams rise to great heights and do a vast amount of damage. It is said that the greatest flood known in this section of the country occurred in 1867, when there was a week of heavy rainfall, followed by a violent rain storm lasting twenty-four hours and seemingly extending over the whole basin. At Butler the river rose 18 feet above its low-water mark, washing away several houses and barns and totally destroying a great many acres of valuable bottom lands lying immediately along the river. Similar floods are reported to have occurred in the valley of Roan Creek in 1861 and in 1870. Droughts are infrequent, and as a rule are neither severe nor long continued, the drought of 1900 being the most severe within the memory of the inhabitants of the basin.

SPRINGS.

A marked feature of the region is the great number of springs, the discharge of which ranges from less than a gallon a minute up, several being of very large size. One of the larger springs is in the village of Allentown, Tenn. The spring basin is nearly 100 feet in diameter and has a discharge estimated at from 8 to 10 cubic feet per second. Another large spring is directly on the bank of the river, at the town of Fishspring. Here there are a number of small streams flowing from crevices in the rock, the aggregate volume being 7 or 8 cubic feet per second. The peculiar feature with reference to this spring—for which it and the town were named—is that in the autumn, when the water of the river begins to grow cold, a large number of fish, especially sun perch, come from the river and enter the basin of the larger spring—a cavern beneath the surface of the earth—where they spend the winter, returning to the river after spring opens and the river water is again warm. Twenty-one hundred fish were caught in one season by means of a trap placed at the mouth of this spring when the fish were returning to the river, and 165 have been caught in a single night, all being very fat. This indicates the existence of a body of water of considerable size beneath the surface of the earth. This supposition is borne out by the fact that about 40 feet from the river an area probably 25 feet square has sunk several feet within the last few years, and a hole has opened in about the center of the depression through which fish can in the winter be caught by means of a hook and line.

TIMBER.

There is a great deal of valuable timber still standing in the basin of the Watauga, only about one-third of the area being cleared and in

cultivation. The character of the timber varies as the stream is ascended, hard wood seeming the predominant growth along the lower part of the stream and its tributaries, but gradually giving place to pine, spruce, or hemlock. On the upper part of Laurel Creek and of the main stream, upon which the most extensive timbering operations have been carried on, the growth seems composed entirely of the latter trees, and the yield of timber is heavy. Evidences of extensive timbering are to be seen over almost the entire basin, the river at the time of both visits—one in the summer and the other in the fall—being full of logs waiting for a rise in the stream to carry them down to the mills. Numerous splash dams have been built on the tributaries and several on the river itself.

MINERALS.

Not many minerals or mineral localities are reported from this basin, the only place where mining rises to the dignity of an industry being at the famous iron mines at Cranberry, N. C., where is mined an iron which rivals in quality and purity the best Swedish ore. There are other deposits of iron ore in the basin, those on the upper part of Roan Creek and on Doe Mountain being perhaps the most noted. Formerly some copper was mined at Elk Knob, just beyond the eastern limits of the basin, but nothing has been done there for several years.

TRANSPORTATION.

The transportation facilities for the greater part of the basin are entirely inadequate. The East Tennessee and Western North Carolina Railroad, from Johnson City, Tenn., to Cranberry, N. C., furnishes an outlet for the products of that part of the basin, and the Virginia and Southwestern Railroad, from Bristol to Elizabethton and thence up Watauga River and Roan Creek, serves the northern part of the basin, but the whole area within North Carolina possesses no railroad, its facilities for transportation being limited to the country roads, which with the exception of the one paralleling the river are very poor, being steep, rough, and full of stones, so that it is impossible for a team to haul more than half a load over them. It is thought, however, that this condition will soon be bettered by the construction of a railroad from Lenoir, N. C., to Blowing Rock, and thence across the basin, probably following the course of the river a considerable distance and connecting with other roads, either at Cranberry, Butler, or Mountain City. Watauga County has recently authorized a bond issue of \$100,000 to aid in the construction of this road.

DISCHARGE MEASUREMENTS.

During the investigation a gaging station was established on Watauga River at Butler, Tenn., and on two of its tributaries—

Roan Creek at Butler, Tenn., and Elk Creek at Lineback, Tenn. The results of measurements at these stations, as well as of the numerous miscellaneous measurements on the river and its tributaries, are given herein; those made on the main river in the following table, and those on the tributaries in the table on page 85.

Discharge measurements of Watauga River.

Date.	Locality.	Hydrographer.	Gage height.	Discharge.
1900.			<i>Feet.</i>	<i>Sec.-ft.</i>
July 16	Elizabethhton, Tenn	E. W. Myers	15.87	450
Aug. 2	do	L. V. Branch	15.77	593
Aug. 16	do	do	16.03	403
Oct. 5	do	E. W. Myers	16.03	348
Nov. 7	do	L. V. Branch	15.27	993
Dec. 28	do	E. W. Myers	15.68	533
Dec. 31	do	Ernest Graves.	15.22	973
July 30	Butler, Tenn	E. W. Myers	1.37	434
Aug. 7	do	L. V. Branch	0.90	214
Aug. 17	do	do	0.84	166
Oct. 6	do	E. W. Myers	1.12	238
Nov. 7	do	L. V. Branch	2.20	591
Dec. 28	do	E. W. Myers	1.40	311
July 16	Watauga Falls, N. C	N. C. Curtis		79
Aug. 10	do	L. V. Branch	6.62	53
Oct. 7	do	E. W. Myers	6.52	60
Aug. 11	One mile above Shulls Mill, North Carolina.	L. V. Branch	4.05	19
Oct. 7	do	E. W. Myers	3.78	23

NOTE.—At regular stations of the Geological Survey gages are installed by which the rise of the river is measured, an increase in the gage height representing an increase in the discharge of the stream. This is true of the measurements in the above table which were made at Butler, Tenn. In making the other measurements in the table, however, bench marks were established and measurements were made, by means of a steel tape, of the distance from the bench mark to the surface of the water. In those cases, therefore, an increase in the gage height means a lowering of the water surface and a corresponding decrease in the discharge of the stream.

WATER POWERS.

The fall of the Watauga River is very great throughout its length, and the selection of shoals for utilization would be largely a matter of convenience, the average fall of the stream in Tennessee being about 15 feet to the mile, and between Shulls Mill and the Tennessee line about 47 feet to the mile, with many short stretches where the fall is much greater. Very little of the vast power in this basin is utilized, however, either on the river or on its tributaries, there being, so far as could be ascertained, only three mills on the main stream, and these all small ones. The first mill is at Watauga Falls. It is a roller flour mill with a capacity of 30 barrels per twenty-four hours. The second one is just below the mouth of Cove Creek, where there is a fall of about 9 feet and a very good location for the construction of dams and buildings. Here there is a small sawmill and wagon shop which uses a small proportion of the water by means of a homemade tub wheel yielding an unknown amount of power.

The first shoal that could be developed into a power of considerable magnitude is just above the North Carolina line, where there is a fall of about 10½ feet, but it is in a deep gorge and at present is so inaccessible that it is of no importance as a power site.

For about 4 miles above this place, or as far as the mouth of Beech Creek, the concentration of fall is very great, and dams of almost any desired height could be built without excessive lengths across the top, and powers could be obtained limited only by the heights of the dams. There is a similar locality just below the mouth of the lower Laurel Creek.

Above this point and on through Valle Cruces there are a number of shoals in the river, but the average fall in the stream is less than that above or below, and since the bottoms are very broad and lie only a few feet above the water level, power could not advantageously be obtained in this part of the course of the river, on account of the flooding of valuable farming lands.

As has been stated, the gorge is redeveloped on a smaller scale a short distance above Valle Cruces, and the slope of the stream becomes very great, being a succession of rapids with large fall and many abrupt plunges. There are a number of places where a dam from 60 to 70 feet high could be built with stone quarried on the spot, while the level tops of the hills would afford a safe and excellent location for buildings; but until this country has made material advances and has provided means of transportation for raw materials and finished products, it is extremely improbable that any development of water power will be made beyond small amounts for purely local needs.

TRIBUTARIES OF WATAUGA RIVER.

DISCHARGE MEASUREMENTS.

During the investigation the following measurements were made of the tributaries of Watauga River, in order upstream:

Discharge measurements of tributaries of Watauga River.

Date.	Stream.	Locality.	Hydrographer.	Gage height.	Discharge.
				<i>Feet.</i>	<i>Sec.-ft.</i>
1900.					
July 19	Brush Creek	Near Carter, Tenn	L. V. Branch	6.77	10.03
Aug. 16	do	do	do	6.82	9.47
Sept. 24	do	do	E. W. Myers	6.94	5.14
Aug. 2	Sinking Creek	Lower ford of Johnson City-Elizabethton road, Tennessee.	L. V. Branch	3.73	5.0
Oct. 4	do	do	E. W. Myers	3.75	4.0
Aug. 2	Buffalo Creek	At mouth, Tennessee	L. V. Branch	5.85	20.0
Oct. 4	do	do	E. W. Myers	5.92	10.0
Aug. 2	Gap Creek	do	L. V. Branch	4.00	7.0
Oct. 4	do	do	E. W. Myers	4.12	3.0
Aug. 3	Laurel Fork of Doe River.	Allentown, Tenn	L. V. Branch	5.19	30.0
Aug. 17	do	do	do	5.50	15.0
Oct. 5	do	do	E. W. Myers	5.67	9.0
Dec. 29	do	do	do	5.05	27.0
Aug. 3	Little Doe River.	do	L. V. Branch	4.42	35.0
Oct. 5	do	do	E. W. Myers	4.73	17.0
Dec. 29	do	do	do	4.90	23.3
Aug. 3	Wilson Creek	One mile above mouth, Tennessee	L. V. Branch	3.67	5.0
Do	Shell Creek	At mouth, Tennessee	do	2.35	14.0
Do	Doe River	Two miles below Roan Mountain, Tennessee	do	8.46	41.3
Do	do	Near Allentown, Tenn	do	5.56	72.0
Aug. 18	do	do	do	5.81	50.0
Oct. 5	do	do	E. W. Myers	5.85	39.3
Aug. 2	do	Above Elizabethton, Tenn	L. V. Branch	5.94	143.4
Aug. 17	do	do	do	6.20	106.0

Discharge measurements of tributaries of Watauga River—Continued.

Date.	Stream.	Locality.	Hydrographer.	Gage height.	Discharge.
1900.				<i>Feet.</i>	<i>Sec.-ft.</i>
Oct. 5	Doe River	Above Elizabethton, Tenn	E. W. Myers	6.23	82.0
Dec. 31	do	do	Ernest Graves	5.23	304.0
Aug. 3	Stony Creek	One-half mile above mouth, Tennessee.	L. V. Branch	6.95	44.0
Oct. 5	do	do	E. W. Myers	7.59	16.0
Dec. 31	do	do	Ernest Graves	4.60	48.0
Aug. 13	Doe Creek	Ivyspring post-office, Tenn	L. V. Branch	5.94	9.0
July 30	do	Mouth of Doe (town), Tenn	E. W. Myers	5.23	59.0
Aug. 13	do	do	L. V. Branch	5.49	26.2
Oct. 9	do	do	E. W. Myers	5.46	28.38
July 30	Mill Creek	At mouth, Tennessee	do	9.48	13.0
July 29	Town Creek	At Shoun Crossroads, Tenn	L. V. Branch	3.48	29.2
Aug. 13	do	do	do	3.82	6.0
Do	Forge Creek	Near mouth, Tennessee	do	4.53	7.0
July 30	Roan Creek	Butler, Tenn	E. W. Myers	1.47	137.0
Aug. 7	do	do	do	1.02	65.0
Aug. 17	do	do	do	0.85	58.0
Oct. 6	do	do	do	0.86	52.0
Nov. 7	do	do	do	1.50	171.0
Dec. 28	do	do	do	1.20	82.0
Aug. 13	do	Key Station, Tenn	L. V. Branch	4.85	5.2
July 30	do	Above mouth of Mill Creek, Tennessee.	E. W. Myers	5.70	60.3
Aug. 6	Dark Ridge Creek.	One-half mile above mouth, Tennessee.	L. V. Branch	4.65	3.0
Do	Little Elk Creek.	At mouth, North Carolina.	do	1.20	6.0
Aug. 4	Blevins Creek	Cranberry, N. C.	do	6.03	5.05
Do	Cranberry Creek	do	do	6.95	5.09
Aug. 12	North Fork of Elk Creek.	At Banners Elk, North Carolina.	do	5.61	7.0
Oct. 8	do	do	E. W. Myers	5.64	4.0
Aug. 11	South Fork of Elk Creek.	do	L. V. Branch	11.96	9.38
Oct. 8	do	do	E. W. Myers	11.82	8.48
Aug. 9	Elk Creek	Lineback, Tenn	do	3.5	70.0
Aug. 17	do	do	do	3.5	56.0
Oct. 6	do	do	do	3.5	53.0
Aug. 6	do	One-half mile below mouth of the Little Elk, Tennessee.	L. V. Branch	7.21	64.0
Aug. 9	Big Dry Run	One-eighth mile above mouth, North Carolina.	do	1.55	0.85
Do	Fogey Creek	At mouth, North Carolina.	do	2.94	1.4
Oct. 6	do	do	E. W. Myers	3.02	2.4
Aug. 9	Beech Creek	Above mouth of Fogey Creek, North Carolina.	L. V. Branch	5.6	7.3
Oct. 6	do	do	E. W. Myers	5.7	7.4
Aug. 9	Beaverdam Creek.	Near Leander, N. C.	L. V. Branch	5.59	7.0
Oct. 6	do	do	E. W. Myers	do	8.0
Aug. 10	Laurel Creek (lower).	At mouth, North Carolina.	L. V. Branch	10.62	4.0
Oct. 7	do	do	E. W. Myers	do	3.09
Aug. 12	Rockhouse Creek	do	L. V. Branch	2.17	16.3
Oct. 18	do	do	E. W. Myers	do	0.8
Aug. 12	Brushy Fork of Cove Creek.	do	L. V. Branch	2.06	5.19
Do	Cove Creek	Above mouth of Brushy Fork, North Carolina.	do	4.31	23.0
Aug. 10	do	At mouth, North Carolina.	do	5.24	12.0
Oct. 7	do	do	E. W. Myers	5.15	14.0
Aug. 10	Dutch Creek	Valle Cruces, N. C.	L. V. Branch	7.42	11.0
Oct. 7	do	do	E. W. Myers	7.37	6.0
Aug. 10	Laurel Creek (upper).	At mouth, North Carolina	L. V. Branch	2.62	10.0
Oct. 7	do	do	E. W. Myers	2.87	6.0
Aug. 11	Moody Mill Creek.	do	L. V. Branch	3.20	4.0
Aug. 10	Boone Fork of Watauga River	Shulls Mill, N. C.	do	2.30	12.0
Oct. 7	do	do	E. W. Myers	2.11	13.0

NOTE.—At regular stations of the Geological Survey gages are installed by which the rise of the river is measured, an increase in the gage height representing an increase in the discharge of the stream. This is true of the measurements in the above table which were made of Roan Creek at Butler, Tenn., and of Elk Creek at Lineback, Tenn. In making the other measurements in the table, however, bench marks were established and measurements were made, by means of a steel tape, of the distance from the bench mark to the surface of the water. In those cases, therefore, an increase in the gage height means a lowering of the water surface and a corresponding decrease in the discharge of the stream.

BRUSH CREEK.

The first tributary of the Watauga which was made the subject of investigation was Brush Creek, which rises near Johnson City, Tenn., and flowing in a general northwesterly direction joins the Watauga a short distance below Carter, Tenn., having a total length of between 7 and 8 miles and draining an extensive area. The drainage basin consists of large but low hills with very gentle slopes, largely grass covered. Probably 90 per cent of the area is cleared land, largely in pasture, but a small part is cultivated in corn and wheat. The soil is deep and fertile. The country rock is a limestone.

The creek has a fall of about 400 feet between Johnson City and its mouth. The water is used by two small mills, too small to be of importance, and there is no definite information concerning them at hand. It is probable that this creek reached its minimum stage in September, 1900, when it was discharging about 5 second-feet. During floods it rises about 3 feet above low-water mark at its mouth.

SINKING CREEK.

The upper or second Sinking Creek, which enters from the south, is the next tributary. It drains a narrow area between 10 and 11 miles long, about three-fourths of the lower part of which is cleared. Its headwaters drain the northwestern slopes of the Buffalo and the Cherokee mountains, a rough and rugged area, densely forested. The characteristics of soil and topography over the lower part of the basin are in every way similar to those of the basin of Brush Creek. The stream was very low at the time it was visited, early in October, attaining its lowest stage during that month. It was carrying 4 second-feet when measured on October 4. During floods it rises about 2 feet.

BUFFALO CREEK.

Buffalo Creek, the next tributary, drains a much larger area than either Brush Creek or Sinking Creek. The greater part of its drainage basin consists of low, flat, and rounded hills, for the most part grass covered. Probably from 85 to 90 per cent of the lower portion of the basin is cleared; but as the stream is ascended the country becomes more rugged, being very steep and mountainous near the headwaters, and is largely covered with forest, though it is probable that three-fourths of the entire area drained by the stream is cleared. It is in the basin of this stream that the great number of sinks which have heretofore been mentioned as occurring near Milligan are to be found. These sinks occur from Milligan to the east and southeast as far as Gap Creek. At the time of the fall visit (October 4, 1900) the stream had reached its lowest stage of flow (10 second-feet). Its maximum flood rise is about 3 feet.

Buffalo Creek has three small tributaries—Dry Creek, Toll Creek, and Powder Branch—all of which enter from the southeast.

GAP CREEK.

Gap Creek, the next tributary entering the Watauga from the south, has a drainage basin which seems in every way similar to that of Buffalo Creek, with the exception that no sinks were seen. This stream reached its minimum stage in the fall of 1900. When measured on October 4 it was discharging 3 second-feet. Its flood rise is about 3 feet at the mouth.

DOE RIVER.

The most important tributary received by Watauga River is Doe River, which rises in the high and mountainous area to the west and north of Roan High Knob, and flows in a general northerly and north-westerly direction, joining the Watauga at Elizabethton, Tenn. Near the mouth of the stream probably one-fourth or more of the valley is cleared land, the cleared areas being the level bottom or terrace land immediately along the river; but about 2 miles above Elizabethton the gorge of the Doe begins, and from that point to Allentown the river flows in a very narrow channel carved out by its waters from the solid rock, which rises on either side in precipitous walls several hundred feet high. Near Allentown, where Doe River is joined by the Laurel Fork and Little Doe River, there is a considerable area of open and level arable land rimmed about by high and steep mountains. Above that place the gorge of the Doe becomes more pronounced, the sides rising higher and more steeply above the water, and the scenery, though confined, is very much grander than that of the lower gorge. A view in the upper gorge is shown in Pl. XXIII. Throughout the gorge the fall averages nearly or quite 100 feet to the mile, the greater part of it being in rapids; sudden plunges are rare. Power in large amounts could be obtained here. Above the gorge the fall averages about half as much, being about 50 feet to the mile.

The water power of Doe River is used at only two places. At Elizabethton water is taken from the stream above the town and is used in the operation of a small cotton mill and several small gristmills. A small woolen mill is also sometimes operated by power derived from the stream. The largest consumer of power was a woolen mill which was burned several years ago and has not been rebuilt. Near Roan Mountain Station there is a small lumber mill using three turbines working under a head of 12 feet, but the amount of power developed could not be ascertained.

Little Doe River.—This stream, which is tributary to Doe River at Allentown, drains an area in all respects similar to that drained by the main stream above the junction, being very mountainous and largely forest covered. So far as could be ascertained there is prac-



DOE RIVER VALLEY, TENNESSEE.

tically no cleared land above 2 miles from its mouth. None of the power of the river is utilized. The time of minimum flow was in September, 1900. The flood rise at the mouth is about 4 feet.

Laurel Fork.—The next important tributary of Doe River is the Laurel Fork, which joins it at Allentown, draining an area similar to that drained by the main stream and by the Little Doe. The Laurel Fork has a large fall and carries a considerable quantity of water, which is used at Allentown by a small sawmill, and just above that place by a combined sawmill and gristmill using a small amount of power and a fall of 16 feet. Another mill is reported farther upstream. It is stated that active lumbering operations are now in progress over the basin of the Laurel Fork and that much timber has been cut.

STONY CREEK.

The next tributary of the Watauga is Stony Creek, which enters the river from the northeast and drains a long and broad valley containing a larger proportion of cleared and cultivated land than either of the streams just described. The cleared land, however, is confined to the level bottoms bordering the creek and to the first bench or terrace—this being all that is susceptible of cultivation, so it is said—and amounts to only about one-eighth of the whole, the remainder of the basin being steep, rugged, and forest covered. At the time of the October visit the stream was said to have reached a point lower than ever before known. It was then carrying 16 second-feet. The high-water mark is about 6 feet above its level at that time.

The average fall of the stream is large, and its waters are used by several mills, all small, the first one being located close to the mouth of the creek and using a fall of 10 feet, the power developed being estimated at about 12 horsepower. The second mill is a short distance above and is a small corn mill operated by a homemade wheel developing an unknown amount of power. The third mill is about a mile above the mouth of the stream and is a small combined sawmill and gristmill using a small amount of power.

ROAN CREEK.

There is no other important tributary of the Watauga until Roan Creek is reached. The watershed of this stream, which joins the river at Butler, Tenn., is in the area between the Stone Mountains on the north and Snake Mountain on the south. The main stream rises near Snake Mountain and flows in a general northerly direction for 7 or 8 miles, when it is joined by Forge and Town creeks—streams which rise in the Stone Mountains and flow to the south—and turns to the southwest, flowing in that direction until its junction with the Watauga. In the latter portion of its course it receives one large tributary, Doe Creek. Roan Creek drains a very large area, known as Johnson County Cove, which has already been somewhat briefly

described (p. 38). The immediate valley of the creek contains practically all of the cleared land in its basin, though small areas have been cleared on some of its minor tributaries where the land is sufficiently level for cultivation. All of the timbered area is still in luxuriant forest growth, consisting principally of oak and chestnut, though maple, locust, pine, spruce, hemlock, poplar, and similar trees are found. Probably 75 per cent of the area is still wooded. Near the mouth of the stream the valley is very narrow and the proportion of cleared land seems smaller than farther toward the headwaters, where the basin bears a close resemblance to the country along the South and Middle forks of the Holston, being rather level and composed of low, grass-covered hills, which are largely cleared. The mountainous areas are high and steep, showing a great deal of exposed rock and being in places densely forested.

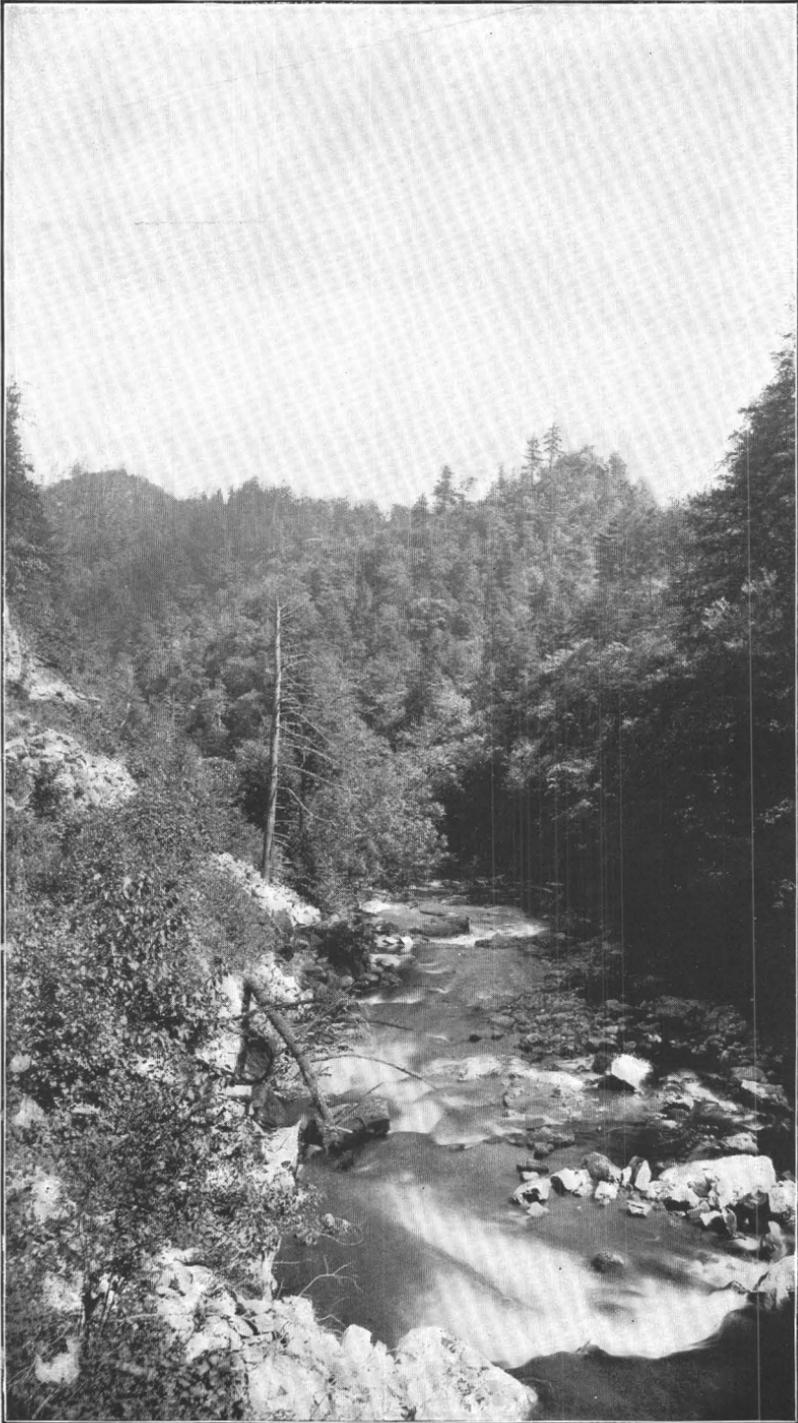
The fall of Roan Creek is considerable, being about 400 feet between the mouth of Doe Creek and a point about 2 miles below Mountain City, Tenn., a distance of 10 miles, making the average fall 40 feet to the mile. Between Shoun Crossroads and the mouth of Mill Creek, however, the fall is much less, and there are stretches where the current is very sluggish and the stream placid. The country rock is no longer a limestone—quartz rock, gneiss, and slate having made their appearance. Although this stream drains so large an area and has so great a fall its waters are used by very few mills.

The first mill on the stream is the roller flour mill operated by Cole & Scott, a short distance above Butler, which has a capacity of 30 barrels a day and is operated by a turbine working under a head of 12 feet. The next mill is 14 miles above Butler and is a combined gristmill and sawmill using a fall of 12 feet and a very small amount of power. The only other mill on the stream is Baker's gristmill, opposite Rhea Forge, where there is a fall of 18 feet.

Roan Creek reached its minimum stage during the fall of 1900. It was measured on August 13 and was carrying 5.2 second-feet. The average flood rise is about 5 feet, though there are records of a much higher rise in 1861 and in 1870, when the stream rose to a height of 8 feet.

Doe Creek.—This stream rises near Mountain City, Tenn., and flows in a direction generally parallel to the course of Roan Creek, from which it is separated by Doe Mountain, joining that stream about 6 miles above Butler. It drains a broad, flat valley which forms a part of Johnson County Cove, and furnishes more utilized power than Roan Creek, its waters being used for the operation of seven small mills.

Mill Creek.—Of the numerous small streams tributary to Roan Creek from the east and southeast none seen were of sufficient importance to justify gaging with the exception of Mill Creek, which enters from the southeast near Baker Gap. This creek was gaged near its mouth and its drainage basin was traversed from end to end. Near



ELK CREEK, NORTH CAROLINA.



ELK FALLS ON ELK CREEK, NORTH CAROLINA.

Roan Creek the proportion of cleared land is very small, but farther up the basin widens, and near the stream all the land has been cleared and is cultivated in corn and wheat or sodded in grass. The cleared land amounts to between one-fourth and one-third of the total area drained by the stream. About 100 yards above the mouth of the creek is Wilson's gristmill, a small mill containing two runs of stones, one for corn and one for wheat, the power necessary being developed by a 16-foot overshot wheel of about 30 inches face, yielding about 12 horsepower.

Town Creek.—This was the only other tributary of Roan Creek that was gaged. It was measured at Shoun Crossroads. There is one small mill on the creek containing two runs of stones, one for corn and one for wheat, and using 5 or 6 horsepower, which is developed by an undershot wheel.

ELK CREEK.

The next important tributary of Watauga River is Elk Creek (see Pl. XXIV), which rises at Banner Elk Creek, on the slopes of the mountain known as Hanging Rock, and flowing in a general direction a little north of west is joined near Elk Park by Cranberry Creek and Little Elk Creek, after which it turns to the north, entering Watauga River about 2 miles above Butler. A gaging station was established on this stream at Lineback, not far above the mouth, where daily readings of the stage of the water surface have been made.

The average fall per mile throughout its length is very great, the headwaters being at an elevation of about 4,000 feet above sea level. Near the mouth the fall seems to be less than the average, and there are large areas of cleared land and broad, level bottoms, from which, however, the wooded mountain slopes rise very sharply to considerable heights. There are small tracts of cleared land as far up the stream as Elk Mills. Between that place and the North Carolina line there is practically no clearing, but beyond the State line the country is more thickly settled and the areas of cleared land are more numerous. The latter are, however, of little importance compared to the total area of the drainage basin. No accurate estimate of the relative proportions of the wooded and cleared lands could be obtained, but it seems safe to say that the amount of clearing is less than 5 per cent of the area.

The amount of power along this stream is very great, but no attempts have been made to utilize it, and it seems improbable that efforts in that direction will be made for many years to come, unless some sawmill requires power to cut the timber which exists in such abundance over the basin. Perhaps the most noteworthy of the powers is Elk Falls (see Pl. XXV), where there is one of the most picturesque bits of scenery to be found in this country. Here there is a straight plunge of 26 or 28 feet, and in the first mile below it the

river falls 53 feet more, while in the 4 miles above it the fall averages 100 feet to the mile.

Above the latter point and as far as Banners Elk there are numerous shoals and rapids which would furnish small and compact powers with from 10 to 40 feet fall; but there is no demand for power in the present state of the country. Near the headwaters, and in particular near Banners Elk, the fall in the stream is very slight, the creek flowing through semimarshy areas and swampy meadows or peaty bogs covered with a dense growth of laurel, and the mountain slopes are covered with fine timber, spruce predominating, though many other varieties occur.

Throughout the basin the slopes are without exception steep, ranging as high as 50 degrees in some cases, and seem to be covered with a deep soil. The country rock over the lower part is a limestone, that of the upper part gneiss and quartz rock. The soil of the immediate valley is fertile and well adapted to agriculture, the principal crops being grass, corn, and wheat, with some buckwheat and sorghum cane. Many varieties of very fine apples are also grown.

The area being so largely forested the flow of the stream is large, the water never falling very low nor rising to great heights, and though the slopes are steep the high water lasts several days. The creek rises about 5 feet at the mouth.

The famous iron mills at Cranberry are located within the basin of this stream.

BEECH CREEK.

The next stream tributary to the Watauga is Béech Creek, which rises on the northern slopes of Beech Mountain, at an elevation of about 5,000 feet, and flows in a general northwesterly direction, joining the river about 4 miles above the State line. It drains a considerable area of steep, high, and densely forested mountain slopes, a very small proportion of the land being cleared. The cleared areas are confined exclusively to a small tract in the basin of Fogey Creek, which joins Beech Creek a short distance above its mouth, and to some of the narrow bottoms and small hills along the main stream for 2 or 3 miles above its mouth. The total area cleared amounts to possibly 5 per cent of the whole basin. Near the mouth of the stream the country rock seems to be a very good quality of granite, but as the creek is ascended this soon gives place to gneiss. The stream never falls very low, and during high water it rises about 4 feet at the mouth, that being the elevation of the highest mark that was found.

BEAVERDAM CREEK.

Beaverdam Creek, the next tributary entering from the north, rises near Baker Gap and Locust Gap, and flowing in a general southeasterly direction joins the Watauga just to the west of the small mountain known as Dyer Knob. For a mile or more above its mouth this

stream is in a deep gorge, the sides, which are very steep, rough, and rocky, and entirely wooded, rising from the water's edge. The fall of the stream in this gorge is considerable. None of it, however, is now used, but the remains of an old mill are to be seen. In this section and for some distance above Leander active timbering operations are now in progress, but so far very little timber seems to have been cut. Above this the valley widens, the hills are lower and the slopes less steep, and much of the land is cleared and under cultivation in grass or grain. On the fork which rises near Baker Gap almost all of the land is cleared except the tops of the hills and probably one-half or more of the country drained by the other forks. Of the total area drained by Beaverdam Creek probably one-half is cleared land, with a deep and fertile soil. The stream attained its minimum flow in the fall of 1900. The maximum rise at its mouth is about 4 feet.

LAUREL CREEK.

Laurel Creek is the next stream of importance to join the Watauga. It enters from the south, after draining a large basin. The creek valley is very rough and inaccessible for about 2 miles above its mouth, the gorge being deep and the sides in many cases sheer walls of rock. The fall in this distance is very great, being 600 or 700 feet. Above this the fall is much less, though it is still large, and a small part of the area has been cleared and placed under cultivation, the clearing being confined to the comparatively level lands lying near the stream and amounting to probably about 5 per cent of the whole basin. The hillside slopes are steep and forested and the soil is generally deep and fertile, although in some places it is shallow and full of rock fragments. Along the upper portions of the stream the soil is swampy in places and seemingly quite acid and in its present state unsuitable for cultivation.

Extensive lumbering operations have been begun in this basin and much timber has been cut on the hillsides, a great many logs being seen in the stream channel awaiting high water to carry them downstream.

It is said that this stream has never before reached a stage of flow as low as during the summer of 1900. The average flood height at the mouth is about 5 feet.

COVE CREEK.

Cove Creek, which enters the river from the north, is the principal tributary in this part of its course and one of the largest entering the stream. It rises near State Line Gap and flows in a general southerly direction for 14 or 15 miles, draining a broad and very fertile valley, which in comparison with the larger part of the watershed of Watauga River is thickly settled. It is estimated that about one-third or a little more of the basin is cleared land, largely in grass, as stock

raising is the principal industry throughout this country, as it is farther to the north. Throughout this valley, with the exception of the mountain slopes to the east and west, the hillside slopes are rather gentle—rarely reaching 30 degrees, the average being not more than 20 degrees—and the bottom lands are broad, with a deep and fertile soil. While the soil of the hillsides is less fertile, it produces very good crops of wheat and corn. From an agricultural standpoint the basin of this stream seems to be more valuable than any part of the watershed of the Watauga yet described.

At times the creek reaches a very low stage of flow, but never lower, it is said, than that attained during the summer and autumn of 1900. The average maximum rise at the mouth is about 5 feet; 6 feet is sometimes reached, and there is one report of a rise of 8 feet several years ago, probably when a destructive flood affected the entire basin of the river.

DUTCH CREEK.

Above Cove Creek the first tributary is Dutch Creek, which enters the river at Valle Cruces. This creek rises on the southern slopes of Hanging Rock and flows in a general northerly direction, draining an area which is very largely forest covered, containing not more than 20 per cent of cleared land, which is for the most part confined to the comparatively level land immediately along the creek. The mountain slopes are high, steep, and quite rugged, and are covered with the original dense forest growth. Like the other streams of the region, the creek reached its lowest stage during the summer of 1900. Its maximum rise at the mouth is from 3 to 4 feet.

LAUREL CREEK.

Laurel Creek is a small tributary entering the Watauga from the northeast, about 2 miles north of Shulls Mill. It drains a very small area, but carries a large quantity of water in comparison with the area drained, the basin being almost entirely forest covered. The cleared land is confined to a few small areas close to the river, these forming less than one-eighth of the basin. The hillside slopes are rugged, steep, and very rocky, and for the most part are covered with a dense forest growth. The stream reached its minimum flow during the summer of 1900. It rises 3 feet in its maximum floods.

BOONE FORK.

Immediately above Shulls Mill the Watauga is divided into two forks, the one to the east being known as the Boone Fork and the one to the west as Watauga River. The Boone Fork rises on the eastern slope of Grandfather Mountain and after flowing almost due east for 3 or 4 miles turns to the north and flows in that direction for about 4 miles, or to its junction with the main fork of the Watauga. There

are no roads along this stream, and its entire basin is inaccessible. The information that was gathered concerning it was obtained from persons dwelling in the country near by. The stream has a great fall, the headwaters rising at an elevation of about 5,000 feet, while the elevation at the junction with the Watauga is about 2,950 feet. Approximately 1,000 feet of this is concentrated in the first mile below the head of the stream, making the average fall per mile below that point between 165 and 170 feet. So far as could be learned none of the fall is used except by the Stonewall mill, a small sawmill and gristmill just above the junction with the Watauga. The sawmill is operated by a Leffel turbine yielding 15 horsepower under a head of 12 feet, which at low stages of the stream requires practically all of the water flowing. The gristmill is operated by three homemade center-discharge wheels working under the same head, but the amount of power given off by them could not be ascertained.

The entire area drained by the Boone Fork is high, rugged, and very mountainous, almost entirely covered with a dense and luxuriant forest growth. The soil is deep and porous, holding back the storm waters to some extent and feeding them out gradually to the stream, which has a large flow, never falling very low. Notwithstanding the great slope of the stream bed and of the hillside slopes, the floods are not so violent as would be expected.

In Part II of this paper, published as Water-Supply and Irrigation Paper No. 63, will be found descriptions of the drainage basins and water powers of the Nolichucky, the French Broad, the Saluda, the Broad, the Catawba, the Yadkin, the New, and other streams of the region.

[For index, see end of Part II, Water-Supply Paper No. 63.]

