

Table of excessive precipitation—Continued.

State and station.	Monthly rainfall in inches, or more.	Rainfall 2.50 inches, or more, in 24 hours.		Rainfall of 1 inch, or more, in one hour.		
		Amt.	Day.	Amt.	Time.	Day.
<i>Tennessee—Continued.</i>						
Springdale	Inches.	Inches.		Inches	h. m.	
Do		2.69	5			
Trenton		2.75	27	1.96	1 30	1
<i>Texas.</i>						
Brady		2.53	28-29			
Coldwater				1.18	0 40	25
Corpus Christi				1.00	0 55	31
Forestburgh				1.50	1 15	19
Fort Elliott				1.03	1 00	25
Gainesville				1.25	0 30	4
Galveston				1.75	1 00	4
La Grange		2.90	30	2.90	2 20	30
Luling				1.04	1 00	30
New Braunfels				1.39	1 30	26
Palestine				1.56	1 15	3
Round Rock				1.08	0 30	28
<i>Vermont.</i>						
Stratford				1.20	1 00	6
<i>Virginia.</i>						
Mossing Ford				1.00	0 20	2
<i>West Virginia.</i>						
Ella		3.98	25-26	1.00	1 00	21
Glenville				1.01	0 20	1
Parkersburg						
Point Pleasant		10.26				
<i>Wisconsin.</i>						
Grantsburgh		4.50	7-8			
Phillips		6.00	8			
Plover		10.91	2	4.50	1 30	3
Do		4.50	3			

Reports received too late to be used in general discussion for August, 1890.

Indiana.	Amt.	Day.
Vincennes	2.83	27

Received too late for publication in July Review.

Arizona.	Amt.	Day.	Time.	Day.	
Crittenden			1.60	0 30	17
<i>North Carolina.</i>					
Douglas	11.65	2.50	24		
Highland	14.48	3.36	23-24		
Marion		3.10	5		
Do		3.02	24		
Raleigh	11.30				
Smithfield	10.05				
<i>Wisconsin.</i>					
Grantsburgh			2.00	1 20	16

**HAIL.**

Description of the more severe hail storms of the month is given under "Local storms." Hail was reported as follows: 1st, Pa. 2d, Ill., Iowa, Nebr., Va. 3d, Ga., Iowa, Minn., Va., S. Dak., Va., Wis. 4th, Colo., Kans., Mich., Mo., N. B. 5th, N. Y. 6th, Ala., Iowa, N. Dak. 7th Minn., Nev., S. Dak., Wis. 8th, Ala., Ariz., Ind., Mich., Mo., Wis. 9th, Ky., N. Y.

10th, Conn., Md., Mass., N. Dak., N. J., N. Y., S. Dak. 11th, Ariz., Colo., Nebr. 12th, Colo., Nev. 13th, Colo., Kans., Mo., Nev. 14th, Colo., Nev., N. Y. 15th, Colo., S. Dak. 16th, Colo., Wyo. 17th, Ill., N. Y., Tex. 18th, Colo., Kans. 19th, Colo. 20th, Va. 21st, Md., N. Y., Pa. 22d, Nebr., Nev., N. Dak., Tex. 23d, Kans., Mont., S. Dak. 24th, Nebr., N. Dak., S. Dak. 25th, Colo., Kans., Mo., Nev., N. Mex. 26th, Colo. 27th, Tex. 28th, Kans., Mich. 29th, Nev., N. Dak., Tex. 30th, Tex., Wash.

**SNOW.**

The Signal Service observer at Harrisburg, Pa., reports that a few flakes of snow fell at that place the morning of the 23d; snow flurries were also reported in Northampton and Northumberland counties, Pa., on the 23d. The Signal Service observer at Sault de Ste. Marie, Mich., states that light snow was reported along the upper Saint Marie River the evening of the 9th.

**SLEET.**

Sleet was reported at Moorhead, Minn., 24th, and in Colo. on the 27th.

**MAXIMUM RAINFALL IN ONE HOUR OR LESS.**

The following table is a record of the heaviest rainfall during August, 1890, for periods of five and ten minutes and one hour, as reported by regular stations of the Signal Service furnished with self-registering gauges:

Station.	Maximum fall in—					
	5 min.	Date.	10 min.	Date.	1 hour.	Date.
	Inch.		Inch.		Inch.	
Bismarck, N. Dak.	0.05	23	0.10	23	0.20	23
Boston, Mass.	0.05	20	0.10	20	0.31	20
Buffalo, N. Y.	0.20	21	0.30	5	0.60	5
Cincinnati, Ohio	0.25	26	0.40	26	1.10	26
Chicago, Ill.	0.20	21	0.27	21	1.00	26
Cleveland, Ohio	0.25	4	0.40	4	0.60	4
Denver, Colo.	0.17	11	0.30	11	0.62	25
Detroit, Mich.	0.15	21	0.20	21	0.75	21
Dodge City, Kans.	0.15	4, 30	0.20	4, 30	0.50	4
Duluth, Minn.	0.25	7	0.32	7	0.78	7
Galveston, Tex.	0.40	4	0.75	4	1.75	4
Jupiter, Fla.	0.35	2	0.70	2	1.80	2
Marquette, Mich.	0.01	28	0.04	28	0.20	28
Memphis, Tenn.	0.32	26	0.60	26	1.24	26
New York City	0.15	10, 22	0.25	22	0.93	22
New Orleans, La.	0.18	24	0.25	19	0.41	19
Norfolk, Va.						
Philadelphia, Pa.	0.35	21	0.53	21	1.16	21
Portland, Oregon	0.05	31	0.05	31	0.10	31
Savannah, Ga.	0.20	10	0.30	10	0.70	10
San Diego, Cal.						
San Francisco, Cal.	†		†		†	
Santa Fe, N. Mex.						
Saint Louis, Mo.	0.15	8	0.21	8	0.50	8
Saint Paul, Minn.						
Washington City	0.30	1	0.55	1	0.82	21
Wilmington, N. C.	0.25	22	0.40	22	1.27	22

\* Not sufficient to register. † No rain. ‡ Rain-gauge not working. † Rain-gauge failed.

**WINDS.**

The prevailing winds during August, 1890, are shown on chart II by arrows flying with the wind. In New England, the upper lake region, and on the northeast slope of the Rocky Mountains the winds were mostly from southwest to northwest; in the middle Atlantic states, south to west; in the south Atlantic states, the upper Mississippi valley, and the southern plateau region, southeast to southwest; in the Florida Peninsula, the east Gulf states, and the lower Rio Grande valley, east to southeast; in the west Gulf states, northeast to southeast; in the Ohio valley and Tennessee, south to southwest; in the lower lake region, and on the south Pacific coast, west to northwest; in the Missouri Valley, and on the middle-eastern and southeast slopes of the Rocky Mountains, south to southeast; on the north Pacific coast, north to west; and in the extreme northwest, the northern plateau region, and on the middle Pacific coast, variable.

**HIGH WINDS (in miles per hour).**

Wind velocities of 50 miles, or more, per hour were reported at regular stations of the Signal Service, as follows: 7th, 56, nw., at Fort Sully, S. Dak. 10th, 60, sw., at Rapid City, S. Dak. 21st, 61, sw., at Mount Killington, Vt. 24th, 58, n., at Valentine, Nebr. 27th, 96, nw., at Mount Washington, N. H.; 74, w., at Green Mountain, Me. 29th, 85, nw., at Mount Washington, N. H.; 54, e., at Winnemucca, Nev. 30th, 50, sw., at Winnemucca, Nev.

**LOCAL STORMS.**

During the afternoon of the 1st a heavy thunder-storm, with vivid lightning, rain, and hail, passed over Philadelphia, Pa. In the evening severe electric storms occurred on the New Jersey coast. A thunder-storm from the west passed over Cincinnati, Ohio, at 1.20 p. m., with heavy rain, and wind 35 miles per hour from the nw. The high wind lasted but 10 minutes,

and was apparently more violent in Newport, Ky., where several buildings were unroofed or otherwise damaged. A destructive rain storm occurred at Mossing Ford, Va., the evening of the 2d, causing the overflow of small streams, and the destruction of crops on low land. At Copal Grove, N. C., a storm caused damage to fruit and forest trees and injured corn and cotton to the value of about \$500. In the morning a wind, rain, and hail storm caused damage to crops and buildings at Otho, Iowa. On the 3d at 4.20 p. m., eastern time, a thunder-storm, with heavy rain and large hail, began at Sioux City, Iowa. Hail continued about 40 minutes; the stones were irregular in shape, some being 1 inch long and  $\frac{3}{4}$  inch thick; the outside of the stones was composed of rough, clear ice and the centre of white, soft ice. About 10.30 a. m., central time, a hail storm from the west passed north of Sibley, Iowa, the southern edge of the path being about  $3\frac{1}{2}$  miles north of that place. The width of the path of hail was about 6 miles, the path of greatest destruction being  $1\frac{1}{2}$  mile, and the path was known to be at least 75 miles in length, and extended over Lyons, Osceola, Dickinson, Emmet, and Winnebago counties, Iowa. The hail-stones varied in size from  $\frac{3}{4}$  inch in diameter to the size of hens' eggs. A number of persons were badly injured by hail, and the damage to trees, crops, and property was estimated at \$150,000. From 10.30 to 11 a. m. a hail storm, moving east, prevailed at Spirit Lake, Iowa. A severe storm swept over the central part of Webster Co., Iowa, in the afternoon, damaging buildings and trees. Destructive hail storms were also reported in southwest Minnesota. At Sioux Falls, S. Dak., a severe hail storm occurred in the morning, lasting about 8 minutes, with wind about 50 miles per hour. Some of the hail-stones were  $5\frac{1}{2}$  inches in circumference. Corn and standing grain, potatoes, and garden vegetables were badly injured. Severe electric, wind, and hail storms prevailed in the afternoon in central and east-central Wisconsin. At Port Huron, Mich., a thunder-storm, with heavy rain, began 12.45 p. m., eastern time, and continued until 1.30 a. m., 4th. The wind attained a velocity of 45 miles per hour at 5.13 p. m., 3d. In the city several buildings were struck by lightning, and one person was severely injured, and in the surrounding country crops were damaged. Considerable damage was caused by a heavy rain and wind storm at Hammond, Ind., on the 3d. A severe electric storm was reported in Cattaraugus Co., N. Y. A severe thunder-storm, with heavy rain, occurred at Cortland, N. Y.; streets and buildings were flooded, and some damage was done by lightning. A rain and hail storm in the evening caused great damage in the southern part of Rockingham Co., Va., and 2 persons were reported killed by lightning in Prince George Co., Va.

On the 4th a heavy wind and rain storm was reported in the southern part of Christian Co., Mo. A wind, rain, and hail storm visited Coldwater, Mich., damaging growing crops. At night a cloud-burst in the mountains, in the east part of Mohave Co., Ariz., caused washouts on the railroad. Advices from Tucson, Ariz., dated the 5th, stated that heavy rain had swollen the rivers, that 60 miles of the Santa Fé road between Benson and Nogales, Ariz., was washed out, and that the Santa Cruz River was flooding the valley. At San Bernardino, Cal., heavy rain, preceded by an unusual amount of thunder and lightning, was reported. Great damage was done in the vicinity of Montreal, Quebec, by a wind storm in the evening, and a heavy thunder and hail storm was reported in New Brunswick. On the 6th a heavy hail storm occurred in Adair and Union counties, Iowa. About 4 p. m. the storm clouds were observed northwest of Orient, Adair Co., and passed slowly to the north of that place. About 5 p. m. the clouds moved rapidly to the westward and when north of Orient moved southward, preceded by a heavy wind for a few minutes, when the air became calm. Heavy rain began falling, followed by hail. The storm moved south into Union county, where great damage was caused to crops. About 7 p. m., central time, a hail storm, probably the same storm felt in Adair and Union counties, moved southwest over the north part of Taylor county. On the 7th at 9.30

p. m., a furious wind storm, from the south, prevailed at Marshall, Minn. A wind storm, with thunder and lightning, moved eastward over Saint Paul, Minn., in the evening, and at Montevideo, Minn., a hail storm badly damaged crops. At Riverside, Cal., a barn was struck by lightning and burned. Cochise Co., Ariz., was visited by a heavy rain storm at night; damage was done at Tombstone and Fairbank. On the 8th a severe wind storm set in at 7.55 p. m., eastern time, at Manistee, Mich. For several minutes the wind was 60 miles per hour from the west. 12 to 15 miles north of Manistee standing timber was blown down, and one life was reported lost. A hail and wind storm passed over Wexford Co., Mich., damaging trees and crops. Severe storms were reported in Ashland, Winnebago, and Eau Claire counties, Wis. At Jacksonville, Fla., a thunder-storm prevailed from 7.45 to 11.15 p. m., during which several buildings and trees were struck by lightning.

On the 9th an electric storm visited Weakley Co., Tenn., during which one man was killed and others injured. On the 10th a heavy thunder-storm swept over Long Island Sound along the Conn. coast, attended by high wind, rain, and, in places, hail, causing damage to corn and tobacco crops in south and southeast Conn. A heavy wind, rain, and hail storm passed over Paterson, N. J., causing damage to buildings and trees, and a heavy electric and hail storm visited Long Branch, N. J. At Rapid City, S. Dak., a thunder-storm, with unusually heavy rain, hail, and high wind, began at 6.30 p. m. and ended 8.10 p. m. The wind reached 60 miles per hour, and a great portion of the city was flooded. The total loss to property in and about Rapid City was estimated at \$14,000, and one man was killed by lightning. The northern part of Orange Co., N. Y., was visited by a severe electric, wind, and hail storm about noon, causing great damage to buildings and crops. On the 12th a severe storm was reported at Belmont, W. Va. On the 14th a thunder-storm, with violent northerly wind, and the heaviest hail and rain storm on record at that place, occurred at Colorado Springs, Colo. The storm began 6.15 p. m. and ended 7.25 p. m., eastern time. Hail began 6.35 p. m. and continued 15 minutes, during which time it covered the ground to a depth of 6 inches. Some of the larger hail-stones were  $\frac{3}{4}$  inch in diameter; their formation was generally spherical, and they were composed of clear ice; but at times the hail fell as a shower of crushed ice without symmetry of form. The total amount of rain and melted hail was 3.18 inches, of which 2.75 to 3.00 inches fell from 6.20 to 6.50 p. m. Within 3 to 4 minutes after the hail began the temperature fell from 75° to 47°. The track of the storm was from west to east; its width was nearly  $1\frac{1}{2}$  mile, and its length about  $3\frac{1}{2}$  miles. The great volume of water did considerable damage to railroad tracks, bridges, etc., and traffic was temporarily suspended. In the city cellars were flooded in the southern portion, and lightly constructed buildings were swept away. The damage was estimated at \$8,000 to \$10,000. The night of the 16th a severe electric storm occurred at Carrollton, Mo. Several barns were struck by lightning, 2 of which were burned, and some stock was killed. On the 17th a heavy thunder-storm prevailed at Gratiot, Ohio, from 12.40 to 1 p. m., during which a barn  $2\frac{1}{2}$  miles south of that place was struck by lightning and burned. The night of the 20th a storm which demolished houses, uprooted trees, and killed stock was reported in Mason Co., Tex.

The evening of the 21st a severe thunder-storm passed over Baltimore, Md.; 1.96 inch of rain fell from 6.05 to 7.15 p. m. Cellars and, in places, the first floors of houses were flooded in the lower portion of the city, and trains on the Baltimore and Potomac Railroad were delayed by washouts. The storm was also very severe in Washington Co., Md., where small hail fell, and where the damage was estimated at \$14,000 to \$15,000. At Philadelphia, Pa., a moderate thunder-storm, with high wind and excessive rain, occurred in the evening. The wind attained a velocity of 40 miles per hour at 7 p. m.; 1.00 inch of rain fell in 25 minutes and 0.35 inch in 5 minutes. During the storm the roof of a car stable, an improperly constructed building, fell in, killing 5 people and injuring 7; 3 horses were

killed and several cars wrecked; damage about \$10,000. A light hail storm passed southeast over Altoona, Pa., at 3 p. m., eastern time, demolishing one stable. A severe wind and thunder-storm moved northeast near Sheridan, Pa., at 5 p. m., eastern time, destroying 5 buildings. A severe thunder-storm passed over Fryburg, Pa., at 1 p. m., local time, damaging buildings. A heavy rain and wind storm passed over Cortland, N. Y., in the afternoon, causing great damage to buildings and trees. At Hiram, Ohio, a violent rain storm, with high wind and lightning, occurred at 9.30 a. m. The storm moved from the southwest, and about 6 miles northeast from Hiram destroyed a house and barn. The track of the storm was about 300 feet wide. There was unmistakable evidence that the storm had a rotary, contra-clockwise motion. Trees thrown down in the left half of the track nearly all lay with their tops toward the right or toward the centre of the track. On the 26th violent local storms caused damage in Ky., northern Tenn., W. Va., and western Pa.; and near McConnellsville, Ohio, very heavy rain fell in the afternoon, flooding small streams and causing great damage to crops, roads, and bridges. On the 27th heavy rain fell in the lower Mississippi valley, and severe gales prevailed on the Gulf coast. On the 28th a severe thunder, rain, and hail storm was reported at Coldwater, Mich., causing damage to buildings and orchards. On the 29th a wind storm passed northward over Payette, Idaho, unroofing buildings and destroying a bridge.

WILKES BARRE TORNADO OF AUGUST 19, 1890.

As already noted this tornado occurred during the passage of Low VI. At 8 p. m. of the 19th a trough of low pressure extended from western Pa. to northern Vt. It had very slight intensity; the lowest isobar (that of 30.00) extended in an oval form 600 miles from ne. to sw. and 300 miles in the other direction. The lowest pressure was 29.92, and the gradient between 30.00 and 30.10 isobars was not far from 1 mm. in 69 miles. The wind velocity for that gradient is 4 miles per hour, and the winds were remarkably low throughout this region. The velocity of this Low from 8 a. m. to 8 p. m. was 47 miles per hour. The following table shows the direction of clouds, and at mountain stations of the wind, at 8 p. m.:

Station.	From—	Station.	From—	Station.	From—
Albany, N. Y. ....	se.	Mt. Washington, N. H. ....	s.	Cincinnati, Ohio ....	w.
Buffalo, N. Y. ....	sw.	New York City ....	se.	Cleveland, Ohio ....	w.
Erie, Pa. ....	sw.	Philadelphia, Pa. ....	sw.	Columbus, Ohio ....	w.
Green Mountain, Me. ....	se.	Rochester, N. Y. ....	e.	Harrisburg, Pa. ....	w.
Killington, Vt. ....	sw.			Northfield, Vt. ....	n.

These stations have been placed in two groups, the first two columns showing direction of clouds from sw. to e., and the third column from a westerly or northerly quarter. It will be seen that the first group lies to the south and east of Wilkes Barre, while the other, with the exception of Harrisburg and Northfield, to the west.

The exact time of the tornado it has been found impossible to learn, the earliest is 5 p. m. and the latest 5.36; the latter was by an engineer who saw the cloud from a point 12 miles distant. It seems probable that the time was not far from 5.32 p. m. in the centre of the city. Just before and after this time on this afternoon the following paths of storms and high winds, with lightning and thunder in most cases, were reported. There were, in all, eight distinct paths traced; the general course in all was toward a point a little north of east. All towns are in Pa. unless otherwise mentioned.

- (A) Wellsborough, thunder-storm at about 2.00 p. m.
- (B) Brushville, about 6 p. m.; Summerville, 5; New Milford, 5.30, one boy killed.
- (C) Philipsburgh, stormy all day; State College, 2.12; Nisbet, afternoon; Rohrsburgh, Stillwater, Fishing Creek, Central, 4.15 p. m.; Benton, some destruction; Bloomingdale, 3 killed, either in town or near by; Register, one fatally injured; Harveyville, 5 p. m., great damage, one killed; Silkworth, 3 killed. Probable loss in these towns, near Harveyville, \$60,000. Muhlenburgh, Dyberry, thunder-storm p. m.
- (D) Blue Knob, thunder-storm p. m.; Bloomsburgh, about 5.10; Shick-shinny, a girl killed; Wilkes Barre, 5.17 p. m., 16 killed, loss \$600,000; Scranton, about 6 p. m.; Kingston, Salem Corners, about 6 p. m.; Blooming Grove, thunder-storm about 7 p. m.
- (E) Hazelton, some damage; White Haven.
- (F) Sinking Spring, 8 p. m., one killed; Reading, about 8 p. m., one killed; Kutztown, some damage, loss about \$5,000; Easton, about 9 p. m.; Greenwich, N. J.
- (G) Gettysburgh, thunder-storm about 8 p. m.; Harney, Md., valuable bridge destroyed; Little Britain, some damage; Christiana, Md.; Phoenixville, 7.40 p. m., ball of fire, 4 inches diameter.

(H) Elkton, Md.; Shiloh, N. J.; Bridgeton, N. J., about midnight 19th; Union Grove, N. J.

It is much to be regretted that the times here given are so uncertain, but in general there is an agreement in the times which shows that violent winds began early in the afternoon in the northern part of Pa., and the paths gradually appear at points farther toward the southeast, the general direction of progression of the violent wind being toward the ene. It has been found almost impossible to sift out conflicting reports and to obtain an accurate list of persons who lost their lives. For example, Mrs. Luther Wilkinson is reported as killed in no less than four separate towns; Lizzie Burns is reported from one town and Mamie Burns from another. By making a careful list of names it is believed that every person killed has been ascertained, though in the case of two, where no names were given, it may be that only one was killed. The total loss of life in all the towns was 27 or 28. The loss of property cannot be accurately stated, but it was probably under \$680,000. The following special reports are given, from Judge Rhone, who has interested himself very much in the tornado investigation, from Professor Santee, and from Mr. G. E. Curtis. Others have also contributed valuable reports. Mr. E. Groux, an instrument maker, was reading a barometer at the moment the tornado passed within 300 feet. He reports that the mercury rose .06 inch and recovered almost instantly.

Judge D. L. Rhone reports: "A bank of clouds lay along the north side of the track of the storm, about forty miles in length as seen from this valley, which extends from Milton to Wilkes Barre. The indications, for an hour or so, were those of the approach of an ordinary thunder-storm from the north-western lakes. The sun was shining on top of this wall of clouds, giving it a reddish or brazen tint. The thermometer stood at about 80°. The wind from the southwest was carrying dark cloudlets into the great cloud-bank at about twenty miles an hour. The track of the cyclone lay beneath the southerly border of this cloud-bank, preceded by frequent intense discharges of electricity. The core of the whirlwind appeared in form like a funnel with its broad top lost in the general cloud-bank, and in color it resembled a great conflagration—that is, a column of dense smoke and flying embers. The distinct apex or nozzle was black. This column moved slightly north of east at the rate of about sixty miles an hour and its nozzle had four distinct motions—(1) on its own axis like a spinning top, (2) forward, (3) a horizontal zig-zag, that is, waving in somewhat angular lines north and south of its forward course, and (4) rising and falling at short intervals. The inverted cone held its main course without reference to the deep ravines and high hills which lay across its path or the amount of resistance met, but the apex or nozzle selected such depressions and ravines as ran closely to and nearly in line with the main line. Its gyration was from left to right when viewed from behind and in its forward course it swirled most of the uprooted tree tops and timbers after it so that everything was carried or was leaning easterly as well as inwardly toward a common centre. As the nozzle rose it sucked up buildings and crushed them inward, but as it fell it crushed buildings and tree tops downward and outward. Much of the time the apex rode from ten to twenty feet above the ground, showing the brazen clouds beneath, hence much of the damage was in the roofs of buildings and their upper stories. The huge funnel at times broke into smaller ones, and each small one bored, twisted, and ploughed away in small spots and patches. The length of the dangling apex or nozzle at no time exceeded perhaps five hundred feet, and none of the objects of any considerable weight were carried more than a few hundred feet in any direction. Light articles, however, were carried four to five miles. There was but little electricity or rain in connection with the gyrating core, but quite a downpour of rain followed in its track. The track of desolation for most of the distance through the country was less than five hundred feet wide. Where the track was narrowest the destruction was most complete."

He also makes the following second report: "My statement, published in the 'Record,' that the core of the cyclone whirled from left to right on its axis is questioned by eminent meteorologists, and after a more thorough investigation I am satisfied that my statement is not correct. There are, in small patches, evidence of a twirling motion either from left to right or from right to left as one may assume the fact to be, but these evidences are deceptive and only exist to the leeward of forests, on the west side of deep ravines, in blocks of cities or other places where counter currents and eddies were formed. For miles and miles through the open country trees, debris of buildings, fences, corn, and objects of every nature lie eastward and inward toward a common centre. That is, objects south of the centre of the track lie north to northeast and east, those north of this centre lie south to southeast and east, the centre objects lying directly east in something like windrows. By the compass in Huntington Valley, where most of my observations were made, for at least twenty miles the main course of the storm was from 10° to 17° north of east. Plenty of trees are found twisted on the stump both northward to eastward and southward to eastward, but it seems in all such cases the tree previously leaned either northward or southward of its stump. None of the uprooted trees were swung around on the ground during or after their fall, save that some few in the centre of the track were dragged eastward after they had fallen, and in one place (Kline's) apple trees were piled up on each other in the centre of track. In swamps trees lie in all directions, but they were lightly set on a hard-pan soil and fell under various degrees of pressure in the direction of their former inclination or were knocked or dragged down or off by others falling upon them. Straw, hay, clothing, and other objects caught up by the storm were dropped down in or near the direction of the storm and not at any great tangent to it. I nowhere see any evidence of a centrifugal force except of the nature of an eddy or such as occurs in autumn when leaves

and thistle-down are caught up and float away, or such twists in trees as before stated. There was not found any piling up of objects except at the centre of the track or immediately around demolished buildings.

"In at least two places where buildings were demolished beehives and flower pots stood undisturbed only some fifty feet away. Along the north and south sides of the track trees lay almost at right angles to the storm, leaning more and more eastwardly toward the centre. At Cambra a field of oats in sheaf was driven into the woods near by with no evidence of having been whirled there. The field was somewhat north of the centre and the sheaves were drifted somewhat south as well as east in line with fallen trees. At Chapin's place, near Harveyville, the centre of the track seems to have been between the house and barn. The north side of the barn roof and the south side of the house roof there were carried off easterly over the garden. The debris of one of the smaller barns there lies northwesterly from the foundation, although the building was south of the centre. Some roofs fell in on the foundation. Bonham's house was pushed northeasterly. Smith's house, further north, one-half mile west of Bonham's, was carried southeasterly. The west end of Harvey's mill, near centre of track, was swung southerly six inches, while the debris of his barn, south of the centre, was carried northwesterly, and a large walnut tree lies north seventy degrees west. Between these buildings apple trees lie with their tops together. Patches of Gregory's sheet-iron barn roof, about one mile east of Harveyville, were driven one thousand feet or more easterly in line of storm. A narrow strip of trees in woods east of Harvey's, on northern edge of track, lie directly west, as also at Hughes', near Cambra, but at other points on extreme southerly edge of the storm the same counter current may be seen as at Cline's and Chapin's. So the evidences multiply on every hand that but one general line of force existed, to wit, inwardly toward the centre of the track and easterly.

"I find the same general drift in Wilkes Barre, but the local eddies and counter currents are more numerous than in the country. Here Judge Dana's office, the pottery, Kittle's smoke stack, Hazard Works, Catholic Church steeple, Robbin's mill, Brown's Block, Lee's planing mill, all in or near centre of track, and all small chimneys, as also ten thousand other things outside of centre of track, drifted directly with the storm to one that eddied out of the main course, as before indicated."

Prof. Santee says: "Perhaps the most striking peculiarity of the track of the storm of August 19th is the waving line which it marks out with points of regularity as it passes across the face of a section entirely irregular in its surface. Everyone is familiar with such phrases as 'The storm followed the river,' 'A storm passed along the side of the mountain,' and kindred expressions. Now this storm, as shown by its track, moved entirely independent of any of the usually recognized local controlling causes, as will be seen by an examination of the line through our valley, the accuracy of which may easily be verified by any person interested.

"Beginning about two miles southwest of Nanticoke its course was about north 60° east to the eastern end of Nanticoke bridge, then curving southward the course is south 85° east about half-way to Butzbach's Landing, then turning northward to a parallel with the first part of course north 60° east it reaches Butzbach's Landing, nearing again to a parallel with the second part of the course south 85° east it crosses near the cemetery at Hanover Green through about a mile of woodland, crossing the corner of the cemetery lot at the cross roads on the middle road below Wilkes Barre through Sively's woods across the Downing rifle range to the southern part of Petty's woods where it makes another turn to the northward, a general course to Five Points north 60° east.

"From Five Points to Mountain Park the course is again south 85° east. There are shorter turns in the course, but they are not probably due to a turn in the general course of the storm. This feature is true in the Huntington Valley tornado as well as that which passed through our valley. The vibration to north and south being regular throughout its course.

"Another noticeable characteristic is the tendency to divide generally into two main lines of damage, especially where the tornado seemed to rise from the earth or where it was descending and before it reached its closest sweep to the ground. These lines again would subdivide, each seeming to have almost the characteristic of a smaller tornado. Thus in Sively's woods, at the west of Downing's rifle range, there are three or four distinct lines of broken timber with intervening spaces left almost untouched, and so, perhaps few have failed to notice in our city, are lines of wreck, and but little damage between. At Ross Street, the southern end of the Hazard Rope Works was crushed by the southern line, while the northern line of the storm was higher in the air at S. Y. Kittle's place. At Market Street the southern line struck Stegmaier's brewery, while the northern line took the top portion of Brown's block. These lines are much more readily traced in the forests because they show more regularly the entire effect of the wind than do buildings which differ so greatly in height and strength.

"Another curious trait is the severity of the storm in deep and narrow valleys. Among the severest points of the storm are the crossing at Fishing Creek, where it struck and nearly destroyed the fine buildings belonging to Hilbert Hulme, Harveyville; where it crossed Huntington Creek at Mallory Wolfe's place, which is between hills on low ground; at the point where it crossed Hunlock's Creek and destroyed the heaviest body of timber on the track; also at the east of the ridge on which the Hillard Grove school stands, and at the east of Elbow Mountain, on John P. Lawler's farm. Each of these points is protected by a high and steep hill at the west from all ordinary west winds, but each is a point of special damage by this storm. While this belt of debris, ranging from fifty to a thousand yards in width, with its divisions

and side currents, indicated by the direction in which various articles are carried, offers a very complex and often contradictory field for study, yet I think there is that which may be reduced to some order. If the track of the storm at any given point be divided into four equal bands running with the track, then the northern and the southern portions would be similar, each consisting of broken trees, lying forward and inward toward the severer central parts of the storm. Of the two central fourths of the storm-track the southern line would consist of debris scattered forward almost directly in the course of the storm, while the northern line would be made up of wrecks lying to every point of the compass, as though the wind had come from every direction. While many exceptions would occur, these conditions would generally be found. Many heavy articles would be found carried to the east, northeast, north, and northwest, while but few would be found carried to the south or southeast. Hundreds of trees lie with their tops to the west and nearly all are in the northern belt of the severe part or main track of the storm. No trees on the southern side of the storm were turned to the west, as far as I have seen.

"During the first few miles of each tornado it is described as white or transparent. The Huntington tornado was a white cloud from the ridge west of Little Green Creek to Frank Bellas' place, where it suddenly became intensely black. The Wyoming tornado passed through nearly the same phase as it crossed Hanover, becoming intensely black as it struck South Wilkes Barre.

"In each case after the storm became black, fire was noticed in the storm by a number of witnesses, whose testimony could hardly be questioned. Taking the various descriptions which I received, the fire in the dark cloud is a prominent characteristic.

"From Fishing Creek to Pine Creek the odor of the air surrounding the storm was very strong and accounts of it agree with the accounts of the smell of ozone and antozone which are produced by lightning strokes, or by a powerful current of electricity passing through oxygen gas. In a portion of its course the storm is described as having a hum like the hum of a rapidly-revolving cylinder.

"While in most of the course there was little or no rainfall with the tornado, yet at Roland Wilkinson's place the people were drenched with a sudden sheet of rain which was in the storm.

"The crushing of trees and buildings downward in places indicates points of great pressure, while the bursting of a closed room near Harveyville seems a plain proof of vacuum or an approach to it.

"Window glass punctured as by a gunshot indicate a speed of the current able to project small bodies at a velocity to produce such results and there are too many such instances to explain upon any other supposition. On the other hand there are many instances of animals, buildings, and persons and various articles lifted and let down again without clear evidence of being touched by any severe wind. A barn with horses in it was lifted over a fence and the horses unhurt. Cattle were carried about without serious harm, as has before occurred in western tornadoes, and in one place a jar of fruit was carried a long distance and only the porcelain lining of the cover broken.

"Many trees along the storm line are withered as by fire, and some are entirely dead though but little broken.

"At one point articles of clothing which were bleaching on the grass were covered with spots which appeared as if scorched by a hot iron."

Mr. G. E. Curtis reports: "The City of Wilkes Barre, Pa., was visited by a tornado at 5 p. m. on August 19, 1890. For the half hour previous to the advent of the tornado an intense thunder-storm seemed to be approaching from the southwest, and vivid lightning flashes marked its gathering fury. On reaching the city the storm apparently increased in energy, the lower clouds began scudding in great circles at tremendous speed, and a sudden gust of wind sprang up, blowing towards the oncoming mass of black cloud. With an increasing roar and darkness, the concentrated storm swept northeastward through the entire length of the city, carrying death and destruction in its path. Sixteen persons were killed outright or soon died from injuries received, and additional deaths were reported as indirectly occasioned thereby at a later date. No carefully conducted estimate of destruction has been made, but \$500,000 is considered to be a moderate estimate of the losses directly sustained by property owners in the tornado path. On September 2d the present writer visited Wilkes Barre to find what could still be learned as to the character of the storm by examining the distribution of the debris and by obtaining the statements of careful observers. And I desire here to acknowledge the kindly assistance rendered by Judge D. L. Rhone, and by the editors of the Wilkes Barre 'Record,' who personally conducted me over large portions of the tornado track, and pointed out many of the salient features still to be witnessed as evidences of the power of the storm.

"The first striking peculiarity observed was the sporadic character of the destruction. The idea of a narrow path within which everything is levelled to the ground, or practically destroyed, had no realization in this tornado. The track can indeed be defined by the destruction that it wrought, but it is of irregular width, and throughout its whole length in the city it exhibits unaccountable alternations of destruction and preservation. The tornado was as lawless and freaky in its behavior as it is mysterious in the development of its power; and after the latter shall have been satisfactorily accounted for, the former will still continue to puzzle and astonish both the ignorant and the learned. In the centre of destruction the tornado was a respecter neither of persons nor of well-constructed brick and mortar, but selected at random the victims of its power. Sometimes strong brick structures were badly wrecked, while weak frame buildings beside them were left untouched. This, however, only in what may be termed the centre of destruction. On the borders of the track damage consisted largely in unroofing, and here well-built houses with firmly-secured roofs, very generally escaped injury.

"With respect to the direction in which trees were blown down, roofs carried away, and debris scattered no complete uniformity exists. Material, especially in the centre of destruction, can be found carried in every direction, but, taking the path of destruction as a whole, the generalization adopted by Prof. H. A. Hazen, that from both borders of the track trees and debris are blown forward and inward toward the centre, seems to be quite well sustained. That such is the case is also confirmed by Judge Rhone after examining the track of the tornado both in Wilkes Barre and for many miles through the forest southwest of that city. A similar observation has been related to me by an observer of the tornado tracks in the forests of Arkansas. It appears, therefore, that, in general, a surface current of destructive force blows from either side inward to feed the vortex of the storm. Many persons described the motion of the tornado cloud as like that of a huge balloon, careening from side to side in its progress, at one time swooping down to the ground, and then floating for a time entirely above it. This conception of the actual behavior of the tornado cloud enables us to understand in some degree the extraordinary freaks in the destruction. The pendant apex of the cloud, like the car of a balloon, swishes into the side of a house here, lashes the corner of a roof there, curls around a church steeple or factory chimney yonder, and further on swirls up a whole mass of timber into its centre, whirling them in its grasp, and dropping them hundreds of feet away. In addition to these general characteristics, some individual phenomena deserve to be specially mentioned. An interesting feature, observed in a considerable number of cases, was that the roof of a house was blown off and the entire leeward side was torn outward with it, leaving the interior of the house wholly exposed.

"In at least one case, however, I found a house, a portion of whose leeward side was blown out on the first floor, while the roof remained intact. This seemed like an actual case of bursting, and could not be explained like the others, as having been dragged outward by the attached roof. I heard also of other houses in which the side blew out, while the roof remained unhurt. A case of equally great interest was a row of light frame tenement houses situated in a depression on the east side of the Lehigh Valley Railroad track near the Pennsylvania Railroad round-house. The houses, each 16 feet in width, were placed five feet apart, and faced about east by south. The path of destruction at this point is of unusual width, and changes from a northeasterly to a more easterly direction. Consequently it is difficult to locate the centre of the path of greatest destruction, or to construct any simple idea of the tornado's behavior. The railroad embankment, 20 feet high, divides the path into two parts, and it is not irrational to suppose that the tornado cloud may likewise have divided itself into two tongues. But, in any case, the phenomenon is this: the house on the south side of the row was

lifted from its foundation and dropped three feet forward and five feet to the left, close up against the middle house. The house on the north side was taken up and set down about three feet backward, and close up against the middle house. The middle house was lifted up and dropped back again in its place without much displacement but with considerable injury—its lower portion being battered in, as if it had been dropped from a greater height than the others. A photograph in my possession illustrates these details.

"Of many other phenomena I will mention only one more. A large smoke stack with an attached piece of casting, the whole mass weighing not less than 400 and perhaps 500 pounds, lies in a yard on the northwestern edge of the tornado track, having been carried fully 500 feet north from a mill in the centre of the track. The mass seems therefore to have been whirled up to an unknown height by a vertical uplift, and then carried by a current of enormous force to the northward until its inertia carried it out of the tornado cloud, after which it reached the ground under the action of gravity and its acquired velocity."

**WATER-SPOUTS.**

On the 20th, between 3.45 and 4 p. m., 4 water-spouts were observed about 4½ miles n.w. from Key West, Fla. 3 of the spouts were well-defined though of small diameter. The water at their base was churned into a mist which extended to a height of about 20 feet. The fourth spout, which developed at 3.50 p. m., extended downward but a short distance from the clouds, although its influence extended to the water, as shown by the mist raised. Each of the formations lasted 5 minutes. The cloud under which the spouts formed was cumulo-stratus in formation, and the spouts developed between 2 rain squalls. On the 30th, at 6.15 p. m., 3 well-defined water-spouts were observed in the Gulf about 2 miles off Galveston Island. The cloud with which the largest spout was connected had the characteristics of a tornado cloud; no rain fell from it, and the sky was clear to the north and south. This cloud connected with 2 others, one to the west and the other to the east, from both of which rain was apparently falling. The other 2 spouts were located between the observer and the rain cloud on the east of the large spout; they were well defined and connected with the water below.

**INLAND NAVIGATION.**

**STAGE OF WATER IN RIVERS AND HARBORS.**

The following table shows the danger-point at the several stations; the highest and lowest water during August, 1890, with the dates of occurrence and the monthly ranges:

Heights of rivers above low-water mark, August, 1890 (in feet and tenths).

Stations.	Danger-point on gauge.	Highest water.		Lowest water.		Monthly range.
		Date.	Height.	Date.	Height.	
<i>Red River.</i>						
Shreveport, La.	29.9	31	2.5	23-24	—0.2	2.7
<i>Arkansas River.</i>						
Fort Smith, Ark.	22.0	30	11.5	12 to 15	0.0	11.5
Little Rock, Ark.	23.0	24	10.1	18	3.2	6.9
<i>Missouri River.</i>						
Fort Buford, N. Dak.		1	6.0	31	2.6	3.4
Sioux City, Iowa		1	8.9	31	6.0	2.9
Omaha, Nebr.	18.0	1	9.1	31	7.3	1.8
Kansas City, Mo.	21.0	1	9.5	31	6.3	3.2
<i>Mississippi River.</i>						
Saint Paul, Minn.	14.5	1	2.4	11, 18	1.3	1.1
La Crosse, Wis.	13.0	1, 2	4.3	12	3.2	1.1
Dubuque, Iowa.	16.0	4	4.8	16	3.0	1.8
Davenport, Iowa.	15.0	1	2.9	17	1.7	1.2
Keokuk, Iowa.	14.0	1	3.2	18, 19	1.6	1.6
Saint Louis, Mo.	32.0	1	10.7	22	7.8	2.9
Cairo, Ill.	40.0	1	12.8	10, 25, 26	9.0	3.8
Memphis, Tenn.	34.6	1	11.1	26, 27	8.1	3.0
Vicksburg, Miss.	41.0	1	12.8	17 to 24	9.0	3.8
New Orleans, La.	13.0	27	5.0	31	3.6	1.4
<i>Ohio River.</i>						
Pittsburgh, Pa.	22.0	27	8.8	31	3.9	4.9
Parkersburg, W. Va.	38.0	28	13.2	5	2.7	10.5
Cincinnati, Ohio.	50.0	30	20.8	4, 5	5.8	15.0
Louisville, Ky.	25.0	31	9.1	6	3.7	5.4
<i>Cumberland River.</i>						
Nashville, Tenn.	40.0	12	12.2	5, 22	2.7	9.5

Heights of rivers—Continued.

Stations.	Danger-point on gauge.	Highest water.		Lowest water.		Monthly range.
		Date.	Height.	Date.	Height.	
<i>Tennessee River.</i>						
Chattanooga, Tenn.	33.0	10	7.5	22	2.5	5.0
<i>Monongahela River.</i>						
Pittsburgh, Pa.	29.0	27	8.8	31	3.9	4.9
<i>Savannah River.</i>						
Augusta, Ga.	32.0	30	12.8	27, 28	5.7	7.1
<i>Willamette River.</i>						
Portland, Oregon.	15.0	1, 2, 3	7.1	25	3.2	3.9

**LOW WATER.**

*Arkansas River.*—At Fort Smith, Ark., the river fell to zero on the gauge on the 12th. This is the lowest stage of water on record at this point since 1856. At Wichita, Kans., the river, which had been dry for weeks, began rising the night of the 25th. The river began to fall again on the 30th.

**FLOODS.**

At Eagle Pass, Ariz., the Gila River was high and impassable ½ of the month. Ditches were much damaged, and freight-impeded or stopped.

**HIGH TIDES.**

Unusually high tide occurred at Key West, Fla., 1st, 2d, and 28th to 31st, and the tide was very high in Pensacola Bay, 26th, 27th, and 28th.