GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR

1881.

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1881.

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NEW BRUNSWICK, December 22d, 1881.

To His Excellency George C. Ludlow, Governor of the State of New Jersey, and ex-officio President of the Board of Managers of the State Geological Survey:

SIR—I have the honor herewith to submit my annual report as State Geologist for the year 1881.

With high respect,

Your obedient servant,

GEO. H. COOK,
State Geologist.

REPORT.

The Geological Survey of the State has been continued through the year, and its work has been, as heretofore, to develop and make public the natural products and resources of New Jersey. The amount of work which has been done is here arranged under the following heads:

I. The United States Coast and Geodetic Survey of New Jersey.
II. Topographical Surveys.
III. Geological Notes.
IV. Ores of Iron and other Metals.
V. Quarry Stones and Statistics.
VI. Clays, Bricks and Pottery.
VII. Drainage.
VIII. Water Supply.
IX. Statistics.
X. Publications.
XI. Expenses.
XII. Persons Employed.
XIII. Work to be Done—Plan for the Coming Year.
APPENDIX—Climate and Meteorology.

I.

THE UNITED STATES COAST AND GEODETIC SURVEY OF NEW JERSEY.

This work is prosecuted continuously, and the progress made during the season just past has been highly satisfactory. Though done at the expense of the United States, it is directed in such ways and to such places as may best suit the State Geologist, and aid him in carrying forward the State Survey. During the past year primary stations have been occupied at Montana, in Warren county, and at Culver's Gap and High Point, in Sussex county, and observations have been taken upon several other stations. And the exact latitude and longitude of seven (7) primary stations and of twenty-eight (28) tertiary stations have been determined by this survey.

In conducting this work every possible means are taken to ensure accuracy. The best instruments are provided, and the observers are trained to wait patiently until repeated and unquestionably accurate observations can be made. This frequently requires weeks, and sometimes months, in a single place, before satisfactory results can be obtained. But the object sought is really obtained, and the exact geographical positions of places are found with astonishing closeness. In the progress of the work this season, the line between Montana and Pickles mountain is one of the lines from the center of a hexagon around Pickles, and the azimuths of this line, as arrived at by computing from the triangles on each side, agree within 1″; the lengths of the line arrived at in the same way differ by less than 4 inches on a distance of 19 miles, the latitudes of Montana agree within 0.006″, and the longitudes within 0.001″. These results are very satisfactory, and they supply a series of reliable points, about which maps may be correctly and safely constructed.

TABLE OF THE LATITUDES AND LONGITUDES OF POINTS WHICH HAVE BEEN DETERMINED FOR OUR SURVEY.

The location of each of these points is marked on the accompanying State map by a small triangle. The longitudes here given agree with the old data of the United States Coast Survey, and they all need to have the correction of 1874 applied before using them. This correction of twenty and six-tenths seconds (20.6″) is to be added to every longitude in the following lists:

GEOGRAPHICAL POSITIONS.

PRIMARY STATIONS.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
Mt. Horeb	40°	36′	39.367″	74°	33′	56 568″
Mt. Olive	40	51	59.879	74	42	32.798
Pickles	40	35	38.260	74	49	06.570
Culver's Gap	41	10	18.486	74	47	22.432
Montana	40	45	50.080	75	03	17.383
Goat Hill	40	20	42.048	74	55	57.452
Haycock	40	29	16 095	75	12	50.970

TERTIARY STATIONS.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
Fox Hill	40°	43′	56.270″	74°	47′	59.380″
Mine Mountain	40	43	16.340	74	46	00 590
North Branch	40	35	52.650	74	40	33.580
Readington	40	34	02.460	74	43	49 590
Cherryville	40	33	42.430	74	54	11 420
Croton	40	29	01.390	74	54	25 970
Gravel Hill	40	35	18.865	75	08	06.800
Bethlehem	40	38	49.950	75	01	18.990
Sand Ridge	40	25	20.450	74	56	54.990
Sourland	40	25	48.960	74	45	19.500
Millstone	40	30	07.441	74	34	27.646
Middlebush	40	29	47.173	74	31	23.106
Somerville	40	34	03.784	74	36	21.717
Raritan	40	33	52.021	74	37	37 324
Reaville	40	29	39.454	74	48	50.492
Pleasant Corner	40	26	25 984	74	51	04.555
Three Bridges	40	31	20.531	74	47	29.891
Flemington	40	30	17.533	74	51	10.617
New Brunswick	40	29	52.726	74	26	28.118
Delaware Water Gap	40	58	05.122	75	06	23.273
East and West Jersey Line on Blue Mount'n.	41	08	44.149	74	50	40 076
Danville	40	52	09 436	74	55	53.363
Hackettstown	40	51	05.479	74	51	59.913
Sparta	41	00	55 958	74	37	56.041
Woodport	41	00	37.555	74	35	10.359
Schooleys Mountain	40	49	44.934	74	47	13 455
E. and W. Jersey Line near Budd's Lake	40	53	46 465	74	44	34.434

TERTIARY TRIANGULATION OF THE STATE SURVEY, BASED ON THE WORK OF THE UNITED STATES COAST AND GEODETIC SURVEY.

NAME OF STATION.	LATITUDE.			LONGITUDE.		
Darlington	41°	04′	40.1″	74°	12′	13.0″
Schraalenburg Church Spire	40	56	22.5	73	59	20.7
Paramus Church	40	59	04.5	74	05	13.6
Ramseys (Church Tower)	41	03	30.9	74	08	12.3
Wykoff Church	41	00	25.1	74	10	06.2
Midland Park Church	40	59	24.2	74	08	11.8
Wayne (Powder Mills Chimney)	40	55	26 5	74	16	13.7
Fairfield Church	40	53	01.8	74	16	38.2
Caldwell	40	50	21 5	74	15	04.9
Boonton	40	55	06.7	74	24	04.4
Parsippany Presbyterian Church	40	51	50.1	74	24	04.5
Morristown First Presbyterian Church	40	47	47.6	74	28	30.7
Watnong	40	50	52.7	74	29	20.8
Warrenville	40	53	50.4	74	50	02.1
Jenny Jump Mountain	40	51	59.6	74	59	01.3
Andover	40	59	07.3	74	44	29.8
Hardwick Church	40	59	42.6	74	51	19.3
Greenville School-house	40	58	02.3	74	49	00.1
Tranquility Church	40	56	36.2	74	47	54.4
Hope	40	54	29.3	74	57	52.2
Belvidere Presbyterian Church	40	49	34.0	75	04	23.4
Mt. No More	40	48	01.2	75	01	16.9
White Hall	40	42	26.8	74	53	41.1
Pohatcong Mountain	40	42	25.7	75	02	45.7
Washington	40	45	53.0	74	58	57.7
Easton	40	41	15.3	75	12	44.2
Seward's Hill	40	47	10.2	74	40	15.5
Mt. Lebanon Church	40	45	19.8	74	54	33.2

II.

TOPOGRAPHICAL SURVEYS.

During the past year the Topographical Survey has been pushed westward across Morris county and the central part of Warren, to the Delaware river at Belvidere. Three hundred and sixty square miles have been surveyed and contoured, making a total area of about twelve hundred and sixty square miles now completed. In addition to this, two hundred square miles have been surveyed with the compass and triangulated, ready to be contoured during the coming season. The state of the existing maps makes it desirable to keep this survey well ahead of the contouring in the future.

By means of a tertiary system of triangulation, based on the work of the United States Coast and Geodetic Survey, twenty stations have been located, making, with those located by the United States Coast and Geodetic Survey, a total of twenty-eight stations on the above area of five hundred and sixty square miles. This will enable the whole to be plotted with accuracy. As the work proceeds, the need for it becomes more and more apparent. Errors of a mile in the location of places on the old maps are quite common, beside gross inaccuracy in details, which, in some localities, makes the maps worse than useless.

It is proposed to extend the work northeasterly during the coming season, so as to cover the important iron ore districts in that direction. Important as are the interests involved in this territory, much of it still awaits its first survey, as the work which has been done there, heretofore, amounts to nothing more than a reconnoissance. There is a large amount of important and interesting detail in the topography, which no attempts have heretofore been made to map, and what little has been done in this line is so faulty that even the topographer, with map in hand, finds it difficult to identify localities.

The levels for our contour lines are referred to approximate mean tide. Lacking a series of observations by which we could determine mean sea level accurately, we were forced to assume the surface of the salt marshes at Newark to be mean high tide. The elevation of said surface would therefore be two and one-half feet above mean tide. This was found to agree closely with the datum of the Delaware and Raritan canal levels, as well as that of the Morris canal.

The levels were subjected to numerous tests to insure their accuracy, and are believed to be correct, within a fraction of a foot, the indicated error at Belvidere, at the close of this season's work, being .15 of a foot.

On the portion of the map which we publish this year, the exact summits of the hills are marked by a small cross, and the elevations appear at the side. These summit elevations are correct within a foot, being a portion of the stations used to determine the position of the contour lines.

The United States Coast and Geodetic Survey has run a line of levels across the State from Sandy Hook to Phillipsburg, during the past summer, and we have been furnished a list of bench marks, with their elevations above mean ocean level at Sandy Hook. Our work will be connected with this at the earliest opportunity, so as to finally refer it to an established and recognized datum.

The work done is all plotted on a scale of three inches to a mile, and the original sheets on this scale are filed in the office. These sheets are, of course, the final authority, and of great value, as no engraving, however carefully executed, has all the weight of the original.

The contours on these maps are the result of careful study and actual levels, determined with the engineer's leveling instrument. Elevations are taken at all important changes of surface, often enough, in fact, to allow the intervening surface to be regarded as a plane, unless otherwise indicated by the sketching, the stations sometimes numbering fifty to the square mile. Between these the ground is carefully sketched to show the minor changes, then in the office the position of the level lines is determined by careful study by the topographer himself, while he has yet the results of his summer's observations fresh in mind. The actual surface is represented almost as accurately as is possible on a scale of three inches to a mile, by a system of contours, allowance being made for the fact that these lines occur only at every ten feet of elevation, hence there may be slight irregularities of surface which fall between two lines, and therefore do not appear on the map.

LIST OF BENCH MARKS.

From the levels of the United States Coast and Geodetic Survey, Sandy Hook to Phillipsburg.

These bench marks show the elevation above mean tide at Sandy Hook. The mean rise and fall of the tide at the tide-house, as registered by the self-registering gauge, is 4.70 feet. This is the mean of all the records from October 21st, 1875, to October 31st, 1881.

The tide-house is near the steamboat landing, at the terminus of the New Jersey Southern railway, and its location is such as to give accurately the ocean level.

The levels were run by Mr. Andrew Braid, Assistant, United States Coast and Geodetic Survey; and the information has been furnished to us by Prof. J. E. Hilgard, Superintendent of the same Survey.

SANDY HOOK.

Primary Bench Mark, A., - - - - - Eleva. 11.432 ft.
Primary Bench Mark, B., - - - - - Eleva. 9.419 ft.

These two bench marks are cedar posts, 4 feet long and 8 inches in diameter, sunk in the ground, with ends projecting above surface of ground about 4 inches. In the center of top of each post is a copper nail surrounded by 5 other similar nails, in the form of a pentagon. The posts are 12 meters apart, and bear east-northeast from the steamer landing (passenger wharf), and nearly northeast from the tide-house, and distant from it about 500 meters (1,640 feet). They are also 95 meters northwest of the red engine-house of New Jersey Southern railroad, and are placed in the edge of a strip of cedars, where the ground is elevated a few feet above the marsh. The southeasterly one is Bench Mark B., and the other one, which is two feet higher, is Bench Mark A.

SANDY HOOK.

Primary Bench Mark, C., - - - - - Eleva. 19.552 ft.

This bench mark is a cross on the head of a copper bolt driven into the wall of the main light-house, at Sandy Hook. The main light-house is an octagonal tower, resting upon a circular foundation of unhewn stones. This foundation projects on all sides about 8 inches beyond the base of the tower, so as to form a sloping ledge.

The copper bolt is a few inches westward of the northwest angle, and 9¼ inches above the ledge above referred to.

SANDY HOOK.

Secondary Bench Mark, No. I., - - - Eleva. 15.509 ft.

This bench mark is the center of the inner edge of the second embrasure from the southwest corner of the fort, at Sandy Hook.

SANDY HOOK.

Secondary Bench Mark, No. II., - - - Eleva. 7.637 ft.

This bench mark is a granite post, prejecting about 2 feet above surface of the ground; it is on east side of track of New Jersey Southern railroad, about ¾ mile north of Highland Station. About 150 meters (492 feet) southwest of it there is a small, deserted shanty. The center of top surface of the stone is the bench mark.

SANDY HOOK.

Secondary Bench Mark, No. III., - - - Eleva. 202.464 ft.

This bench mark is a mark on top surface of a heavy granite post near Navesink light-house. The post is deeply imbedded, and its top projects about 1½ feet above the surface of the ground. It is 13 (42.6 feet) meters south of the southernmost tower of Navesink Highlands light-house.

SANDY HOOK.

Primary Bench Mark, D., - - - - Eleva. 207.579 ft.

This bench mark is the bottom surface of a square cavity (about 1 inch square,) cut on a sloping ledge at southeast corner of base of southernmost light-house tower at Navesink Highlands light.

U. S.
It is marked thus— B. ☐ M.
1881.

SANDY HOOK.

Secondary Bench Mark, IV., - - - - Eleva. 9.283 ft.

This bench mark is the bottom surface of a square cavity (one inch square), cut on the north wing-wall of the west abutment of bridge over the South Shrewsbury river, at Seabright. The top of the wing-wall forms a series of steps, and the bench mark is cut on the first step below the top.

It is marked thus— B. ☐ M.

SANDY HOOK.

Secondary Bench Mark, V., - - - - Eleva. 3.499 ft.

This is the bottom surface of a square cavity, cut on the south pier of the draw-bridge, known as the Oceanport draw-bridge, about 1½ miles north of the Branchport station, New Jersey Central railroad.

It is marked thus— B. ☐ M.

It is on west side of railroad and some distance below its level.

SANDY HOOK.

Primary Bench Mark, E., - - - - Eleva. 38.499 ft.

This bench mark is the bottom surface of a cavity, cut in center of top of a marble post, set in the ground in the yard of the house of Rev. B. F. Leipner, at Red Bank, N. J. The marble post is over 5 feet in length, and buried so that the top projects about 5 inches above the surface of the ground. The house of Mr. Leipner stands at southwest corner of Monmouth and Pearl streets. The bench mark is close to southeast corner of the house. The top of the stone bears the following inscription:

U. S.
B. ○ M.
1881.

MIDDLETOWN.

Toll gate 1 mile from Middletown, - - - Eleva. 41.290 ft.

MATAWAN, N. J.

Secondary Bench Mark, VI., - - - - Eleva. 55.083 ft.

This is the center of a triangle cut on the east corner of a flag-stone in front of Benjamin Tuttle's front gate, Main street, Matawan. It is about ⅓ mile from the station of the New Jersey Central railroad.

This bench mark was first established in 1870, but since that time has probably settled considerably. It is not a good permanent mark, and probably was not so intended.

MORGAN STATION.

Secondary Bench Mark, VII., - - - - Eleva. 5.611 ft.

This bench mark is the surface of stone in center of triangle, cut on top of the southeast pier of the draw-bridge, at Morgan station, of New Jersey Central railroad (Long Branch division). The bridge crosses what is known as "Cheesequake creek."

NEAR SOUTH AMBOY.

Secondary Bench Mark, VIII., - - - Eleva. 14.580 ft.

This bench mark is near South Amboy, where the Camden and Amboy division of Pennsylvania railroad crosses above the New Jersey Central railroad. The Pennsylvania railroad bridge is supported by two piers, or rather stone walls. A mark was cut on the southeast corner of the west wall, about 2½ feet above the level of the New Jersey Central railroad track, and a triangle cut around said mark.

This bench mark is not important, as Primary Bench Mark F. is not far off.

PERTH AMBOY.

Primary Bench Mark, F., - - - - Eleva. 7.782 ft.

This bench mark is between Perth and South Amboy, on one of the piers of the long bridge across Raritan bay. It is on the pier on which the north end of the draw-bridge rests (east side of track), and is, as usual, the bottom surface of a square cavity, 1 inch square and ½ inch deep.

It is marked thus—

F.
B. ☐ M.
U. S. C. and G. S.
1881.

METUCHEN.

Secondary Bench Mark, No. IX., - - - Eleva. 83.641 ft.

This bench mark is a slight circular concavity, bounded by a triangle, cut on the west end of the south wall (near base) of the stone bridge near Metuchen tank station of Lehigh Valley railroad. By means of this bridge the Pennsylvania railroad crosses over the Lehigh Valley railroad.

NEAR SOUTH PLAINFIELD.

Secondary Bench Mark, X., - - - - Eleva. 63.860 ft.

This bench mark is the bottom surface of a square cavity (1 inch square by ½ inch deep), cut on top of stone abutment at northwest corner of a small iron railroad bridge, about 150 meters (492 feet) east of South Plainfield station of Lehigh Valley railroad.

It is marked thus— B. ☐ M.

NEW MARKET.

Secondary Bench Mark, XI., - - - - Eleva. 49.179 ft.

This bench mark is the bottom of a square cavity, cut on top stone of south end of west abutment of a small railroad bridge, about ¾ mile west of New Market station, Lehigh Valley railroad, and 200 meters (656 feet) west of mile post (13 miles to Perth Amboy).

It is marked thus— B. ▭ M.
XI.

BOUND BROOK.

Secondary Bench Mark, XII., - - - - Eleva. 32.483 ft.

This bench mark is the bottom surface of a square cavity, cut on top of stone abutment (northeast corner) of New Jersey Central railroad bridge, about ¼ mile east of Bound Brook station.

It is marked thus— B. ▭ M.

BOUND BROOK.

Secondary Bench Mark, XIII., - - - Eleva. 35.744 ft.

This is the bottom of a square cavity (1 inch square by ⅛ inch deep), cut on top stone of west end of north abutment of road bridge over Raritan river, at Bound Brook.

It is marked thus— B. ▭ M.
XIII.
1881.

SOMERVILLE.

Secondary Bench Mark, XIV., - - - Eleva. 81.800 ft.

This is the bottom surface of the circular cavity in the metal on top of the "true meridian" granite post, in grounds of the court-house, Somerville.

SOMERVILLE.

Primary Bench Mark, G., - - - - Eleva. 91.280 ft.

This bench mark is, as usual, the bottom surface of a square cavity cut in stone, at the base of the easternmost pillar of the front of the court-house, Somerville.

G.
It is marked thus— B. ▭ M.
U. S. C. & G. S.
1881.

NORTH BRANCH STATION.

Secondary Bench Mark, XV., - - - - Eleva. 84.880 ft.

This bench mark is the bottom surface of a square cavity cut near the top of the southwest corner of New Jersey Central railroad bridge, over the north branch of Raritan river, a short distance east of the North Branch railroad station.

It is marked thus— B. ☐ M.
XV.

ANNANDALE.

Secondary Bench Mark, XVI., - - - Eleva. 355.049 ft.

This bench mark is about 1 mile east of Annandale station (New Jersey Central railroad). It is the bottom surface of a square cavity cut on a projecting stone, about the center of the north abutment of overhead road bridge. The bench mark is a little below the level of the railroad track. The stone is hard, blue limestone.

BLOOMSBURY.

Secondary Bench Mark, XVII., - - - Eleva. 326.180 ft.

This bench mark is the bottom of a square cavity cut on top stone of northwest corner of stone bridge (railroad) over wagon road, ¼ mile west of Bloomsbury station, New Jersey Central railroad.

It is marked thus— B. ☐ M.
1881.

NEAR PHILLIPSBURG.

Secondary Bench Mark, XVIII., - - - Eleva. 262.986 ft.

This bench mark is the bottom surface (center) of a square cavity cut in coping stone at east end of north parapet of stone bridge (New Jersey Central railroad) over the Morris canal, about 1½ miles east of Phillipsburg.

It is marked thus— B. ☐ M.
1881.

EASTON, PA.

Secondary Bench Mark, XIX., - - - Eleva. 214.401 ft.

This bench mark is the bottom surface of a square cavity cut on top of a pier (north side of New Jersey Central railroad track) of bridge across the Lehigh river, at Easton. It is on the pier at the west end of wide part of bridge.

U. S.
It is marked thus— B. ☐ M.
XIX.

EASTON, PA.

Secondary Bench Mark, XX., - - - Eleva. 357.186 ft.

This is the bottom of a square cavity cut in foundation stone at west corner of the jail, at Easton. The front of the jail is built of red sandstone and the foundation of blue limestone.

EASTON COURT-HOUSE.

Primary Bench Mark, H., - - - - Eleva. 363.488 ft.

This bench mark is the bottom surface of a square cavity cut on the sill of a blind window on east side of Easton court-house. This side of the court-house has two blind windows, but the one used is the one nearest to the front of the building.

U. S. C. & G. S.
It is marked thus— H.
B. ☐ M.
1881.

III.

GEOLOGICAL NOTES.

The encroachments of the sea upon the low-lying lands of the shore are matters of common observation along the whole eastern coast of the United States. The greatest and most noticeable effects are seen as the effects of violent storms, rather than of any gradual advance of the water upon the upland. In our own State there has been a considerable breadth of land worn away within the last hundred years, all along the seashore from Sandy Hook to Cape May. Through the favor of the Superintendent of the United States Coast Survey, we are furnished with two surveys of the seashore, from the Old Shrewsbury inlet, southward to Deal, a distance of about eight miles. The first of these surveys was made in 1839, and the second in 1867, the interval between the two being only 28 years. The following table gives the breadth of land worn off by the action of the waves at various places along these surveys:

	Latitude.	Feet.
Opposite old Ocean House, near Shrewsbury inlet	40° 23′	225
	40° 22′	165
	40° 21′	225
	40° 20′	360
	40° 19′	330
Opposite old Long Branch Hotel	40° 18′	375
	40° 17′	309
Opposite Whale Pond	40° 16½′	405
	40° 15¾′	525
	40° 15′	360

The hard upland on the Delaware bay shore, at Town Bank, 3 miles above the Cape May steamboat landing, has been much worn by the action of the water. The first settlement in Cape May was made here in 1685, and as the land was early sold off in farms, which were marked by permanent monuments, it becomes easy to measure the amount that has been worn away since the original surveys were made. Nathan C. Price, Esq., of Cape May city, has taken much pains to ascertain how much the land lines which terminated on the bay shore have been shortened by the wear of the waves. His determinations are based upon several old surveys lying on the shore, beginning at the mouth of New England creek, and extending north a mile and a half—

1.—At 63 rods north of New England creek a line has been shortened......................	350	feet in	187 years.
....	352	"	69 "
....	281	"	55 "
2.—At 189 rods north of New England creek a line has been shortened......................	1,040	"	187 "
3.—At 350 rods north of New England creek a line has been shortened......................	860½	"	156 "
....	352½	"	69 "
....	281	"	55 "
4.—At 427 rods north of New England creek a line has been shortened......................	722	"	156 "
....	352½	"	69 "
5.—At 511 rods north of New England creek a line has been shortened......................	600	"	138 "
....	352½	"	69 "
....	281	"	55 "

And in many other places along the shore the wear has been equally great, though it is not so well marked by careful surveys. At Cape Island the shore has worn away a full mile since the Revolution, and since this survey has been in progress the wear along the beaches northeast from the cape, has been so great as to require very considerable changes in the map of the shore lines. In many places along the seashore the wearing away of the beaches leaves thick, dead, salt meadow sod, uncovered and projecting out on the ocean shore. There is no such sod now growing along the shore outside of the beaches, and this old sod must have grown when the beach was between it and the sea, and when it was a part of the meadow between the beach and the upland, or possibly a part of one of those pieces of sod which grow in the *slashes* between the sand hills of the beach. In either case it marks a considerable change in the location of the shifting sand hillocks which fringe the ocean shore.

These changes by themselves would excite but little attention, as they may, very plausibly, be ascribed to continued breaking of the waves against the sand, and its yielding a little at a time to their powerful action, and it is not necessary to assume that they have any more effective action now than they had a hundred years ago.

But if the salt and other tide-marshes are examined, other evidence is found which tends to show that the level of high water is above where it used to be. In many places dead trees are to be seen standing in the shallow parts of the marshes. This is specially the case along the back or westerly side of the beaches, where the sand comes very gradually down to the marsh, and cedar trees grow on it. Many of these can be found dead and still standing, and with the beginnings of salt grass growing around them. And along the edge of the upland, but in the marsh, stumps of trees can be seen projecting above the surface of the meadow, and when these are examined it is found that their roots are still, in many cases, quite sound and firmly imbedded in the solid ground, where there is every appearance of their having grown, except that they are below the meadow surface, which is at high-water mark. Such stumps and roots are found in almost every ditch which is dug in the salt meadows near the upland. Travelers going out from New York, in crossing the marshes between Bergen Hill and Newark, or Paterson, can see, from the car windows, any number of such stumps still standing. They can be seen in all the marshes down the seashore. There is a most extraordinary show of them in the marshes near Dennisville, in Cape May county, on Delaware bay side. They are very plainly shown at the mouth of Alloways creek, in Salem county, and good places for examining them are so numerous that it is not necessary to specify more.

As the salt marshes are at the level of high water, and storm tides cover the whole of them, it will readily be perceived that these trees, the remnants of which are all that now remain, could never have grown there when the ground was overflowed by the tide or by salt water. In some places this effect of the tide is explained by assuming that alterations in the coast and various inlets have given freer access for the incoming tide, and that it rises higher than it formerly did on this account. But the change is so general, and so much alike in all places, that the explanation offered does not apply well to all the cases. The changes which have taken place between the marshes and the upland, are not observed to be gradual and uniform in their advances; they take place more in the manner which some of our geologists have designated as *catastrophism*, than in that which they have called *uniformitarianism*. Some violent storm, with favorable wind, occurs at the time of spring tides, and carries the sea-water higher and farther inland than it has been known to go before, and farther than it may again be observed to go for a generation afterwards. But it destroys any vegetation which is not natural to salt water, and it is observed that the original growth, especially that of wood, does not spring up again, but the lower portions of the land remain a permanent gain to the marshes. Such a storm of wind without rain occurred at Barnegat, September 3d, 1821, as I was informed by Eli Collins in 1856, when the wind was so violent and the tide so high that the spray was carried against the windows in the village, and the salt was seen upon them after the water dried off. And for three miles inland from the shore the salt carried in was enough to kill the leaves upon the forest trees. The remembrance of this is still retained among the people there, and there has been nothing equal to it since that time. This tide was equally high and well marked in Cape May. In a letter from Capt. Thos. Townsend, of South Seaville, and Dr. J. F. Leaming, of Cape May court-house, they say that there is a tradition, that early in the eighteenth century the tide crossed the main road at South Seaville, though no such phenomenon has been observed within the present memory. In 1821 the tide filled an upland pond in Capt. Townsend's field. This was during the September gale, so called. No such occurrence has taken place since.

The old road from Newark to New York was down Ferry street and the Neck to near the present plank road bridge, and so across the Passaic, the marsh and the Hackensack, on to Bergen Hill and Powles Hook ferry. About the beginning of the present century a new road was built, going out of Newark from Bridge street, crossing the Passaic there, and directly on from there across the East Newark upland and the marsh and swamp straight towards the Hackensack and Bergen Hill. A considerable portion of this road was built through a thick and growing cedar swamp, as I was informed by one who had frequently traveled over the road. This swamp became the resort of tramps and, it was said, of thieves and robbers, so that it was dangerous for single passengers to go through. On this account it is said to have been set on fire and burned. No trees have grown on the marshes since that time, though the stumps and many trunks of trees still remain. Some thirty years ago a nursery of trees was begun on this marsh, but the tides came so high on it that the young trees soon became diseased, and the project was abandoned. And it was common to see much of the surface of the marsh covered with tide-water until it was banked in and protected from the tides. Now, though it is below the level of high water, shrubs and trees again begin to grow on it, and no doubt will continue to thrive, unless the dike surrounding it should be broken so as to let in the tide-water.

At Barnegat, in 1856, Mr. John Collins, then 80 years old, and who had always lived there, told me that he did not believe the tides run higher than formerly. He said the wood had been killed off the meadows for a breadth of 30 chains, since his recollection, and that he does not know the reason, as he thinks extra high tides are not so common as formerly. He thinks the meadows have filled in. In many places where there were tide ponds 50 years before, there is now good mowing ground. He remembers that it was said by the Indians, that the whole of what are now the meadows, were formerly all a swamp and bushes. The soil, where the trees have died on the meadows, is still sandy, though a sward of black grass, salt grass and some fresh grass, of considerable strength, has filled over it.

Some portion of encroachment of the sea upon the land has evidently taken place *since the country was settled,* for in some places the stumps of trees which have been cut down with the axe are found. I saw one of these several years ago, when the tide was almost even with the cut top of the stump. A letter addressed to Thomas Shourds, of Hancock's Bridge, Salem county, upon this subject, brought from him the following very circumstantial and interesting reply. He says: "In regard to the stumps below the first fast land on the shores of Alloways creek, they are fully 2½ feet below the surface of the meadow at the present time. From Alloways creek, south along the fast land (known as the Neck), for forty or fifty rods from the fast land, is found the solid upland, covered with stumps and timber, by digging through mud about two feet. The owners of the property at this time, fully confirm these statements. I have a map in my possession Richard Hancock (Fenwick's surveyor) made for Edward Wade, who purchased 1,000 acres of the proprietors. The western line commenced on Alloways creek, a few rods from where we found those stumps, running south 800 rods. I am satisfied the second survey included all the lowland, now covered with two or more feet of mud. The map was made in 1676.

"Second. The two sluices in the Monmouth River Bank Company thee inquires about, have certainly settled from 2½ to 3 feet from the time they were first laid. Thee further inquires 'if it can be caused by the weight of mud upon them?' I think not, because all sluices are well piled before the sluice is put in its bed, so called.

"Doubtless there have been great changes of the land on the shores of the Delaware and its tributaries since the first European settlement, more than 200 years ago. There have been many islands of excellent soil, many of them heavily timbered, a number of them in the present century. There was an island in Elsinborough, about one-half mile below where Fort Elsborg was located when it came in possession of Col. Benj. Holme, in 1765, contained 10 acres of farm land. I myself remember when large trees were standing upon the island; at the present time not a vestige of the once fertile island is seen. One mile and a half further down the bay, a short distance below the Black ditch, a small stream empties into the Delaware, was an island called Money Island. At the beginning of the present century it was of considerable size, and well timbered. About one-quarter of a mile from the bay, by tradition the noted Capt. Leach, or Blackbeard, and his piratical crew wintered one winter, and procured their fuel from off the island—that was in the first decade of the last century. The few scattered inhabitants believed that Capt. Blackbeard buried his treasure on the island, hence the name of the island. A large portion of the island has been dug over in pursuit of the treasure. I have no doubt he knew how to take care of his money better than bury it on that lonely spot in the salt marsh. I assisted in laying on the tide bank for the purpose of reclaiming the salt marsh where the island was situated, about 20 years ago; at that time there was no part of the once famous island, but was covered with salt grass. There are two other islands that are worthy of notice; they are located about seven miles below the mouth of the Alloways creek, situated in the township of Lower Alloway creek, surrounded by salt meadow. The first is known as Round Island; it is one mile from Delaware bay and two miles from the fast land. John Harris, who served seven years in the regular army during the revolution, purchased the island in 1803. One of his grandsons told me it contained 40 acres of good upland at the time of purchase. John cleared off the timber and built comfortable farm buildings, and then himself and family resided about three miles from the nearest inhabitants. He was very thrifty and purchased another island about a mile nearer the main fast land, being about the same size as Round Island; on the latter he cleared up, erected buildings, and went there in 1812. In 1814 he died, leaving the last-mentioned island he left to his youngest son, Benjamin Harris. Round Island he left to his eldest son, Stretch Harris; he married and was very successful in accumulating so much so that in 1826 he purchased a large farm on the main land, about 1½ miles from Hancock's bridge. After moving off the island he rented it, but the salt tide encroached on the upland. His sons, after his death, moved off the buildings and abandoned it for farming purposes. At the present time it is used for the pasturage of cattle, but a small spot is left which could be called upland. Ragged Island was farmed by Benj. Harris for a short time, but in 1827 he sold it on account of the water making such rapid strides upon it, and purchased elsewhere.

"At the present time, what were once two fertile islands have but a few acres of upland to mark the spot where they were located. There has been no change in the mouth of Alloways creek since 1774.

"In regard to the stumps found along the shores of Alloways creek, below the first fast land, some of them show marks of the axe. I do not know that thee is aware that one-half of the meadows that is reclaimed by the tide-banks in Salem county formerly were swamps. The timber upon the lowlands was principally cottonwood and maple. Many of the swamps have been cut and the land cleared since my remembrance. There is a reliable tradition that all these fine meadows near Salem were heavily timbered 150 years ago. The most fertile meadows in this county are located on Oldmans, Salem and Alloways creek. In 1640 a colony from New Haven, Conn., explored Alloways creek. They found a large quantity of cottonwood on the lowlands bordering on the creek, and they named it Cotton river, which name the Sweeds called it until 1676, when a company of Friends from Monmouthshire, Wales, purchased lands of Fenwick, bordering on the river. They changed the name from Cotton to Monmouth river. The flood tides on Delaware bay and its tributaries certainly rises 6 inches higher than they did 50 years ago. The cause I will leave to those who are better acquainted with the workings of our planet than I am. I only, in some degree, know the effect without the knowledge of the cause."

A recent letter from Dr. Maurice Beesley, of Dennisville, Cape May county, was written in reply to one of mine, asking for information in regard to the advance of the salt water upon the swamps and upland. The letter is dated August 22d, 1881, and he says:

"All I can attempt to do will be to give you what has occurred, under my own observation, for 53 years past, within 3 or 4 miles of me. Then the meadows and cedar swamp below the main road, where you now see everything killed, were in fine order, and clover grew on the meadows. There was a large scope of cedar, some trees 2 feet in diameter, and I had on my place 5 acres of cedar swamp. About 1860 the bank was suffered to go down, and all the cedar—mine and Mr. Holmes'—was killed, while 4 acres of young swamp, next the main road, escaped. We repaired the banks in 1864, but about three years ago they were again suffered to go down; in consequence, the old bankers said, the tide rose higher than it had done in former years, which was plain to every one, and the water being so much salter than formerly, it killed maples, brush and all kinds of wood, as well as cedar, and killed the balance of the cedar near the main road (which had to be worked), and left everything dead, as you recently saw. About two years ago, Mr. L. Edwards' tide mill at the landing, in letting in water to fill their pond at high water, have killed several acres of young cedar, 40 years growth. A heavy crop of cedar was cut off it, and no salt water has ever before got into it. Last September I was compelled to work 1½ acres of cedar swamp on my place, just below Johnson's mill, near me, in consequence of being killed by the salt water. This swamp has never been disturbed before, and was about 70 years growth. Another circumstance which goes to prove conclusively the rise of water; Mr. John L. James, one of the owners of the Johnson mill, and a millwright, says, that after putting the sheeting of the mill precisely as it always had been, he was compelled, about eight years ago, in order to keep clear of the back-water, to raise the foundation 8 inches higher than formerly, and is now troubled occasionally by back-water.

"The meadows below, where we formerly had black grass and clover, is now a dense mass of cattail and quagmire."

Capt. Thomas Townsend, of South Seaville, and Dr. J. F. Leaming, of Cape May Court House, have favored the Survey with the following very full and interesting letter upon the changes on the sea side of that county, together with some thoughts as to the cause of these changes. Their letter is dated November 19th, 1881, and is as follows:

"The varying heights of our neap, spring and storm tides, render the question as to any permanent change of relative level between the ocean and the land a difficult one.

"It would seem that, from some cause, other than destruction of the timber by cutting, by drifting sand, and by storm tides, our coast is, in some degree, approaching the upland.

"For instance, there must have been a time when, for a long period, circumstances favored the growth of the red cedar, oak and other trees, so as to produce a broad belt of timber, skirting the whole coast. We may now look in vain for any new growth bordering the ocean. Cut down the present growth, and there seems to be nothing to impede the advancing sand hills.

"If this encroachment of the ocean had always existed, no timber could have taken root and matured. External and accidental circumstances are the same now as they were a hundred years ago. Seemingly either the ocean tides are higher or the beaches are lower, as we must suppose, to alter the conditions of the forest growths as we see them now. It is peculiar to many of our beaches that the northeastern portions are rapidly washing away, while the southwestern portions are building out. How far this phenomenon is explainable by the reflex action of the Gulf Stream encountering the cross currents of our rapidly-flowing inlets, is a nice question for investigation. This reflex current is southward, ordinarily, about 2 miles per hour, and during strong easterly winds, when the Gulf current is forced miles shoreward, this reflex current is much stronger. This is the time when most of the washing away of the beaches occurs, and, without doubt, these causes have much to do with the present changes, and yet this reflex current and other causes enumerated have always existed, and the question still recurs, Why should these causes now act so as to wash away the beaches, when in former times they not only did not so act, but permitted a growth of heavy timber, some of it now hundreds of years old, unless there has been a change of level between coast and ocean. The coast has receded a full quarter of a mile within the memory of the present generation. On the eastern part of Ludlam's beach the whole of the timber has been demolished, the sand hills have washed across the meadows and filled up the nearest thoroughfares, where formerly there was 8 or 10 feet of water at low tide, and the work is still going on.

"Confirmatory of this theory, there is a large stump, as large as a barrel, still to be seen on Dr. P. M. Way's farm, near the edge of the meadow. This stump is cut low, only a few inches above the surface. It has been here from the earliest recollection of the oldest inhabitant. When or how it grew we can only conjecture, but certain it is that the tide did not rise then as it does now, or it could never have attained its present size. The shortness of the stump shows that the land has not been removed by natural causes, and the land cannot have risen by gradual accumulation or it would have covered the stump. This is the most reliable level mark of which we have any knowledge, and it would seem to show that relatively the edge of the upland must be lower than formerly.

"*Per contra.* Suppose that in ages long past, the five fathom bank, lying fifteen miles off the coast, were the shore of the ocean, and that ever since the ocean had been gradually wearing the shore away, as it is now; that within this shore and between it and the main-land were elevated portions or islands, as we now frequently see on extensive meadows, it is easy by this supposition to account for the growth of cedars and other timber, as it is found upon our beaches, and this supposition, in the light of present facts, has nothing unreasonable in it, and will effectually demolish our former position, founded on the growth of timber skirting the coast.

"Dead red cedars are often seen, but they may have been killed by accidental circumstances. The salt spray carried from the ocean or bay by a strong gale of wind, has been known to blight the leaves of cedars and other trees as if a fire had passed through them. Accidental high tides, as when they are forced upon the coast by an unusually fierce gale of wind, can hardly be brought into an estimate of this change of relative level.

"There is a tradition here that, early in the eighteenth century, the tide crossed the main road near this place (South Seaville), but no such phenomenon has been observed within present memory. Indeed, two large walnut trees have grown and passed away upon the site of this occurrence. In 1821 the tide filled an upland pond in Capt. Townsend's field. This was during the September gale, so called, in 1821. No such occurrence has taken place since.

"The reflex current from the Gulf Stream, setting shoreward, passes to the southward of Brigantine shoals, and strikes the coast most forcibly about Corson's inlet, where the greatest changes in the coast occur. Its force is then deflected and the west end of Ludlam's beach appears to be gaining seaward. This deflected current seems to pass southward as far as Hatteras, when it passes outward to the Gulf Stream again. This may account for the apparent subsidence of the coast. Indeed, the evidences of subsidence are so contradictory, and the circumstances or causes acting to produce changes are so various and so imperfectly understood, that it would seem that this whole question must be left to scientific investigation or to the development of some evidence now wanting to determine the facts."

The reflex action spoken of in the above letter refers to a remarkable difference in the direction of the currents in the Atlantic along our shores. The change in these currents takes place opposite Barnegat inlet, where, as is plainly shown on the map, there is a considerable difference in the trend of the coast line. From Barnegat north the direction of the shore is almost north, while from that point southerly the coast bears southwest, and the currents passing along the shores have their courses corresponding in the same directions. The beaches, also, are affected by the currents. An inspection of a map of the beaches shows that those north of Barnegat all have their heaviest and wooded ends at the south, and they taper out low and bare at their northern ends, and if they increase in length by any movement of the sand, it is always in low and slender tongues of sand, extending towards the north. It was in this way that the old Cranberry inlet and the Shrewsbury inlet were entirely closed by the extension of sand bars across them from the south towards the north. Those beaches south of Barnegat have all the conditions of form and extension reversed. The highest and timbered ends are at the north, and the low and narrow sand banks are at the southerly ends; and any extension of the beaches is at their southwest ends. It was in this way that the inlet between Long beach and Tucker's Pond beach was closed by the extension of Long beach entirely across it. And several of the other inlets south of Barnegat have been temporarily closed by sand bars extending across them from the north towards the south. These effects show that there are currents running along the shore from Barnegat both north and south, and it is the southern of these which they have designated the *reflex* current.

The amount of this encroachment of the sea over the land is not plainly shown as yet. The buried stumps and logs have been found at the bottoms of ditches as far out into the meadows as they have been dug, and 4 or 5 feet down. At Dennisville, in the marshes where there is much timber under the surface, I found logs, by probing with a slender iron rod, at a depth of 17 feet below the surface, and this is the lowest that I have been able to find any evidence of this kind.

It is not uncommon to find buried timber and fragments of trees in the gravelly earth of South Jersey. In some of the deep wells which have been bored such timber has been found at great depths. In a well at Cape May City a sound log was found at the depth of 84 feet below the surface. But these belong to a much earlier period of geological history, and must not be confounded with those first mentioned, which are found only on the surface, or, if buried, are only covered by swamp muck and earth.

There is another class of phenomena still to be distinguished from those which we have described. There is everywhere along the borders of the upland, a belt of fine, alluvial soil, which is quite different from the gravelly soils so common on most of the uplands. They appear to have been formed by the wash from the uplands, when the ocean level was 8 or 10 feet higher than it is now, and this deposit was made in the edge of the water. In this alluvial earth are found imbedded shells of the clam, oyster, periwinkle, and indeed all the kinds of shells now common in the waters on the sea side and bay side of the State. Such shells have been dug out at Barnegat, below Beesley's Point, at Leesburg, and above Port Elizabeth, on Maurice river, on the Manumuskin, near Port Elizabeth, and at other places in Cumberland and Salem counties, but always near tide water and but a few feet above it. These deposits evidently belong to a different period and order of movement from that now going on, and as the whole amount of that change of level was but a few feet, it is most probable that the present one will not be of any greater extent.

The rate at which the change indicated may be going on, it is not easy to determine. From some observations made I had thought it probable that it was about one-quarter of an inch a year. But some other persons familiar with our shores, and fully satisfied of the fact that the tides are advancing on the upland, still think my estimate of the rate too large, and that it does not amount to one-eighth of an inch per year. There is nothing by which to accurately determine this rate except some careful and long-continued observations. And it is with much satisfaction that we begin such a series of observations now. The United States Coast and Geodetic Survey has had a self-registering tide-gauge set at Sandy Hook since October 21st, 1875, and continuous records made from it up to October 31st, 1881, and from these they have deduced the mean ocean level at that place, and practically that of the open ocean. From this mean tide mark levels have been taken and transferred to the main-land, and bench marke have been fixed at numerous points across the State, as described on page 13. Our Survey proposes to take this mark for that of a datum plane, and from it to set permanent bench marks along the shore at various places, and to so describe them, with their proper elevations, above this datum plane, and their locations, that they can be referred to at any long time after this, and questions as to the change of level can be definitely answered. The work of setting these bench marks will be done next season, if possible.

IV.

ORES OF IRON AND OTHER METALS.

IRON ORES.

The iron ores mined in the State are mostly magnetic. The amount of hematite is small in comparison with it, and it all comes from three localities. The magnetic iron occurs in the gneissic and other crystalline rocks belonging to the Archaean or Azoic age, and the extent and boundaries of these rocks have been described several times in the publications of the Geological Survey. To prevent fruitless searches and waste of capital and labor, it is proper again to call attention to the descriptions of these Archaean areas, as given in the "Geology of New Jersey," in the annual report for 1873, and in that for 1879. The division into the four belts known as the Ramapo, Passaic, Musconetcong and Pequest, was made in 1873. In the report for 1879 their boundaries were delineated. (See pp. 39, 41.) The map accompanying this report indicates the Archaean rocks by the crimson lake shade of color, but the belts are not shown separately. This area or part of the State is, therefore, the iron-bearing district. If with it we should include the limestone valleys, in which the hematite ores are found (and which are colored blue on the map), we should have the whole area of the iron district. The capitalist seeking localities for investment, and the prospector searching for ore, must confine their investigations and explorations to this part of the State. The total area of our iron-bearing district includes 772 square miles of the Archaean and about 300 square miles of Paleozoic rocks, amounting to near 1,200 square miles, or about one-sixth of the area of the State. The magnetic iron ore is limited to the first, the hematite to the second. Although comparatively small, the first of it amounts to about half a million of acres, reduced to that standard of measurement, and when it is understood that single acres have yielded 100,000 tons of ore, we can get some conception of the possible capacity of such a territory.

The geological examination of the iron-ore producing belts, and of the iron ore beds, in their relations to the enclosing rock masses, cannot proceed with advantage further without accurate maps. Careful surveys of the surface, including the outlines and shapes of its hills, mountains and valleys, must precede any final and conclusive geological explorations. Surveys of this kind are necessary to the prospector also, to enable him to locate his lines of magnetic attraction and to connect ranges of ore outcrop or mines. Their importance is so well understood by the successful explorer, and the value of the help of this kind already given by the map of the Survey is so considerable, that it is unnecessary to enlarge upon the subject in this place. Apprehending the needs of the people, the Survey has had the work of constructing such maps of the iron ore district in progress for two years past, and the surveys already completed cover nearly three-fifths of the district. These surveys are based upon the United States Coast Survey triangulation work, and they include the accurate location of the roads and streams, and of all the topographical features of the surface. The elevations and ranges of hills and valleys are determined by contour lines 20 feet apart. The area thus surveyed will be mapped soon and be ready for the next annual report. It covers all of Morris county, excepting the northern parts of Pequannock, Rockaway and Jefferson townships; the Ringwood valley and the mountain ranges on each side of it, to the New York line, in Passaic county; all in Warren county, except the southwest end of the Pohatcong, Scott's and Marble mountains, and Lebanon and a part of Tewksbury township, in Hunterdon county. Another season's work will cover nearly all the remaining portion now unsurveyed. But the greatest and most important results anticipated from these surveys are the assistance in the study of geological structure. By their aid we hope to be able to discover the clue to the occurrence of iron ore, and consequently exhibit on future maps the geological belts in which ores are to be found, and the intermediate barren belts of country wherein ore is not to be found. Such maps would at once indicate the more probable localities for finding ore, and would therefore be essential guides in searching for it. This end is the practical one sought after, although the explanation of geological structure and the history of the changes which have worked together to produce the present surface configuration are desirable. To accomplish this result will be the solution of what is now a problem, and of which at present the geologist knows little more than the miner. In fact he has only the accumulated data furnished by the miners at all the localities opened by them. The success in the green-sand marl and in the plastic clay belts, in discovering the horizons or locations of valuable beds, warrants and encourages us to labor for and expect a like success in the iron ore region. The difference here is the greater complication of structure by uplifts and faultings through an almost immeasurably greater length of time, as these ore beds are in our oldest or first (Archaean) rock.

No systematic field work has been done in the iron ore district, excepting the prosecution of the surveys for the topographical maps referred to above. A very few localities have been visited, and the following notes of them and of other new enterprises were obtained at that time, supplemented by valuable data furnished by our correspondents entirely familiar with them. The statistics of iron ore will be found further on and under the head of "Statistics." From the figures of the United States Census, which were gathered with great care and attention to details, the value of the annual output of our mines is ascertained to be about $3,000,000. The capital reported was $6,201,761. It is undoubtedly low, although the risks ordinarily attending mining enterprises are great, and require that the ratio of product to capital should be much higher than it is in agriculture, or even in commerce and in manufactures. The value, however, represents actual production by labor, as in the mine the highest average valuation of our ores for a year only is less than 50 cents per ton. Considering a term of years for its extraction, the value is reduced to a minimum. Practically, the ore in the State unmined is of little value, and scarcely to be credited to our resources; only when taken out it becomes such, and in affording labor at profitable rates it gives employment to our population. The mining of our ore means development of our resources. And it must never be forgotten that the time may come when iron shall be obtained from other and cheaper sources. For example, our red shales and our green-sands contain enough to supply the world, whenever it can be found out how to extract it profitably. To limit the resources of chemistry and metallurgy to the magnetic or other existing ores of iron for all time, would be to put a bar to progress.

In regard to exhaustion, it is entirely safe to say that our mines and the ore localities are at this time more promising than ever before. The prospects for large production are better than they were ten years ago. That we have discovered all the more valuable beds is altogether improbable. Taking the list of 115 mines, as they appeared in the Geology of New Jersey, printed in 1868, we note that about one-fourth have ceased to be producing. But in their place we have more than twice as many others which are productive. The outlook, so far as production goes, is good, and the signs of exhaustion are not worthy of present consideration. But, in any event, development and progress means putting our ores in the market as rapidly as we can do so at remunerative rates.

The increased railroad facilities are also greatly helping develop our mines and affording cheaper access to markets, as well as stimulating the search for additional localities.

NOTES ON SOME IRON MINES AND ORES.

A few notes are here inserted on some openings for iron ore, on which new work is being done.

Swayze Mine.—The West End Iron Company is now working this mine, and is taking out between 2,000 and 3,000 tons of ore per month. Although not a new mine, it is a re-opening after having been abandoned by the Lehigh Valley Iron Company. It deserves notice for the novel mode of transporting the ore to the Central railroad line by means of a wire rope tramway. This is the first one constructed in the State. Mr. Heft, the superintendent, says: "We can transport 150 tons of ore over our tramway from mine to cars, a distance of 4,000 feet, in 10 hours, for a cost of 10 cents per ton. I think that this mode of carrying ore from mines to railroads deserves a careful inspection by all persons in the mining business." There are many places in the State where this system of carrying ore might be used with economy. It is in successful operation at one of the mines of the Greenwood Iron Company, in Orange county, New York.

Chester Mine.—A small vein of ore was opened in September near Horton station, and east of the Skellenger mine. It has been followed down about 30 feet, and about 400 tons of ore taken out. It is sulphurous, and looks like the Hacklebarney ore. The dip is southeast. The work is so far one of exploration, and is being carried on by Richard George.

Wrightneour.—This place was once worked by a Mr. Henderson. It has been re-opened by the Greenwood Lake Iron Company, and a shaft has been sunk 50 feet deep, from which a drift has been cut in the vein 40 feet. Both the walls are found and 5 feet apart. The ore is about 4 feet wide. It is said to be rich and free from sulphur, but contains too much phosphorus for Bessemer pig.

Silverthorn or Kean Mine.—This mine was described in the annual report for 1879. It was re-opened in the summer of the past year and worked to the end of the year, and produced about 1,600 tons of good ore. It is leased by the Messrs. Large, of White House. The contract for the present year will lead to a largely increased output.

In the Pequest belt there is considerable activity in re-opening old localities and developing them and in searching for new locations. The new railroad lines will give the best of facilities for shipping the ore, which up to this time have not been enjoyed along the Jenny Jump range, excepting near the Pequest.

Lanning Mine.—A fine vein of ore has been opened by the Oxford Iron Company, on the Lanning farm near Oxford Furnace. It has been recently opened, yet it gives promise of being a rich and valuable mine. An average sample of the ore gave the following results, viz.:

ANALYSIS:

Magnetite	73.610	per cent.
Manganese Oxide	0.635	"
Sulphur	0.265	"
Titanium	0.000	
Phosphorus	0.000	
Lime	4.821	"
Metallic Iron	53 290	"

The Kishpaugh Mine has been stocking its ore, awaiting the new railroad completion. It continues as promising as ever, and is remarkable for the ease with which the ore is broken down.

On the adjoining **Cook farm** a vertical shaft is being sunk to meet the Kishpaugh bed near where it crosses into the latter property. The depth reached is 60 feet. It is expected to strike the ore at 200 feet. The result will be awaited with interest, as it is quite a *new departure* in our State, in the methods of searching for ore. But there is no reason why the same system of sinking vertical shafts may not be tried elsewhere to intercept ore beds at considerable depths. Of course there are the risks of thinning out of the ore, or of faults displacing the beds, but from the very general uniformity in the structure now known and proved at so many localities, such risks are not very hazardous and come within the sphere of any energetic and strong mining company.

Stinson Farm.—The Lackawanna Iron and Coal Company is putting down a second shaft on this property. It is said to be down 123 feet, and in ore 1 to 3 feet wide all the way. The ore appears to be nearly vertical as followed by the shaft.

Garrison.—Scranton and Humphreys have opened within three months a bed of magnetic iron ore on the farm of Robert L. Garrison, which, at the surface, has a breadth of 15 feet of wash ore. It has been opened by an adit or cut which is 10 feet high at the back. There is a good foot wall, but as yet no hanging wall has been reached. The attraction is said to be good on a northeast line, varying from 8° to 90° in amount of dip or deflection of the needle.

Davis' Place.—This place has been purchased by A. Pardee, and some ore has been taken out and shipped.

Cummins' Mine.—This place was opened during the year. It has been purchased by the Musconetcong Iron Works Company, and has been further explored by them. The main shaft, 27 feet by 12 feet, is down about 30 feet (vertical) in the ore; and thus far no walls have been found. The intention is to sink 50 feet deep and then stop. About 400 tons of ore have been taken out in the course of the sinking of the shaft. The ore is blue in color and rich. The cut near the Cummins house exposes a breadth of 10 to 15 feet of ore, which varies somewhat in purity, some of it being lean, while in spots it is very rich.

An average sample of the ore washed was analyzed with the following result:

ANALYSIS:

Silica	16.31	per cent.
Metallic Iron	56.54	"
Manganese	1.77	"
Sulphur	2.80	"
Phosphoric Acid	trace.	
Titanium	none.	

The belt of attraction on this place and on the adjoining properties to the northeast and to southwest, is remarkable for its constancy, strength and breadth. It is one of the most remarkable lines of attraction in the State. No openings have yet been made on the Scranton property at the southwest.

Towards the northeast, Swayze and Bulgin have opened the vein on the property of Robert Ayres, and found the ore much like that of the Cummins mine, and within 6 to 8 feet of the surface.

Stockholm Mine.—This mine has been opened by Messrs. Edsall & Howell, on the farm of George W. Greer, about a mile from the Stockholm depot of the N. Y. S. & W. R. R. Co. There is a long line of attraction, and Mr. Howell reports a bed 11 feet thick, as just opened. The ore is a promising one, as shown by the following analysis, viz.:

ANALYSIS:

Metallic Iron	67.10	per cent.
Sulphur	0.61	"
Manganese, as Mangano-Manganic Oxide	3.74	"
Titanic Acid	3.60	"
Phosphorus	trace.	
Silica	0.32	"

Ores from Samuel R. Losey.—Franklin Furnace, Sussex county. A line of attraction has been detected in the valley of the Wallkill, between

Ogdensburg and Franklin Furnace, on lands of Mr. Losey, and he sends the samples for analysis. He has carefully averaged the ore from all that has been uncovered. One of the samples contains a considerable percentage of limestone. This is designated "light ore," the other, containing no limestone, he has named "black ore;" but they are from different portions of the same line of attraction, and are both valuable ores if they can be found in sufficient quantity to mine.

LIGHT ORE:

Silica	2.160	per cent.
Metallic Iron	38.430	"
Manganese, as Mangano-Manganic Oxide	0.625	"
Sulphur	0.140	"
Phosphorus	0.028	"
Phosphorus Equivalent to Phosphoric Acid	0.064	"

BLACK ORE:

Silica	22.57	per cent.
Metallic Iron	44.10	"
Manganese, as Mangano-Manganic Oxide	0.48	"
Sulphur	1.64	"
Phosphorus	0.05	"
Phosphorus Equivalent to Phosphoric Acid	0.12	"

COPPER ORES.

With the improved methods of working copper ores, increased attention has been given to utilizing the lean copper ores which are found so abundantly in some parts of our State. The old mine at Griggstown has been re-opened; some examination has been made of the Schuyler mine ores at Belleville; work has been done in some of the openings in Washington valley back of Plainfield; a new opening has been made at the old Bridgewater mine east of Somerville, and some others are said to have been tested. The only one of them that we have visited is the Bridgewater mine. This mine was worked many years since, and is said to have yielded a great deal of good ore. The opening that has been made is on southwest face of the mountain, the property of Mr. A. H. Hovey. A drift has been carried in directly under the trap rock, for a distance of 150 feet. It follows the general dip of the rock, which is 10° or 12° towards the northeast, and for the whole distance in the shale, for a thickness of about two feet, is so permeated by the copper ore, or almost transformed into that ore. Beautiful specimens of red oxide of copper, and small quantities of native copper are found.

From a pile of perhaps 100 tons of ore at the mouth of the mine an average sample was carefully made up and analyzed. It yielded 15 per cent. of copper. There is nothing to indicate that this was any better than the average ore which the layer will yield. And this outcrop of ore extends along the southwest face of the mountain from near Pluckamin to Chimney rock, a distance of four miles. The bed slopes back at a very moderate angle, so that it can be conveniently worked for a great distance towards the northeast. The ore which is in sight on the dump, and in the sides of the drift, give promise of a very valuable mine.

V.

QUARRY STONES AND STATISTICS.

BUILDING STONE.

Stone adapted to the ordinary construction of foundations, cellar walls, and rough, bridge and wall work, is found in all the northern and central parts of the State. The numerous outcrops of gneissic and granitic rocks, of white, crystalline and common blue limestones, of sandstones and arenaceous, or gritty beds in the slate formation, are so numerous and so widely distributed that they can be worked at a great many localities. Quarries for local use are known in almost every township. In Sussex and Warren counties the blue limestone is most generally employed in both rough work and also in the construction of substantial and elegant buildings. Newton, Deckertown, Hackettstown, Washington and Phillipsburg, all contain good examples of such stone buildings. While this stone has found a large use at home, it has not been shipped away to any extent. Where conveniently located for working and near transportation lines, it may be possible to work some of the outcrops profitably for markets beyond that at home.

The gneissic rocks are found in a few localities in thick beds, and jointed so that large and regular blocks can be quarried out at comparatively small cost. Of the quarries which have been opened and worked to any extent, that at Dover alone is kept steadily in operation. It furnishes a large amount of stone annually for railroad construction along the line of the Delaware, Lackawanna and Western railroad. The same rock occurs along the New York, Ontario and Western railroad, from Pompton to Franklin, and at several points its outcrops have been opened for stone. The Sussex railroad and the Central railroad lines also cross this rock. A large quarry was opened a few years ago near Franklin, on the mountain east of the village, but the place, although promising, was soon abandoned. The stone was adapted to heavy work. The transportation appeared to be too expensive to enable it to compete with stone coming by water routes.

Our crystalline limestones have not developed into marbles to any marketable extent. The attempts to open marble quarries at Upper Harmony, in Marble mountain, on Jenny Jump, and near Andover, have failed to continue as early prospects promised. The so-called "rose-crystal marble" of Jenny Jump mountain, near Danville, is certainly a beautiful stone for interior ornamental work, and the construction of the Lehigh and Hudson railroad within 1½ miles of it will give it access to markets hitherto shut out by reason of distance from any lines of transportation. Of the unique and variegated serpentine and calcite rock, at Montville, it may be suggested as a novelty for some interior work. Generally, our white limestones are not uniform, nor so fine crystalline as to allow of polishing, and they do not appear to be sufficiently free from joints and seams to yield large-sized blocks.

The Potsdam sandstone which is found at a few localities in Warren, Sussex and Morris counties, is not now worked anywhere steadily. It has been quarried at Oxford Furnace, near Danville, at Franklin Furnace, and in the Pohatcong valley, near Washington. It occurs in regular beds, and is generally soft enough to dress readily, although at some localities it is very hard. The bedding and the joints serve to make it work out in rectangular blocks. A locality near Beattystown was observed the present season, where it was to be had in heavy and very regular blocks on the surface. It has not been fully appreciated as a building stone, because of the very narrow and limited extent of its outcrops, which are rarely near railroad or canal lines.

The Green-Pond mountain conglomerate is used in Morristown to a limited extent only, and that more on account of its strange appearance than for its ease of working. It is obtained from bowlders only. Excepting for its use in two localities it could scarcely be put in our list. It is, however, a beautiful stone and effective in the mass. But it cannot be polished, nor even tool-dressed with economy.

FREESTONE AND SANDSTONE.

The largest of our quarries of building stone, and the most extensively worked, and the most noted, are in the triassic rocks of the red sandstone belt of our State. Quarries have been opened at a great many places in Bergen, Passaic, Essex, Somerset, Middlesex, Mercer and Hunterdon counties, which are mostly on the rocks of this formation. This sandstone was used in Bergen and Passaic and Essex, at an early day, in building houses, and many of the substantial old farm-houses are built of this stone. Its durability has been well tested in them. It was used early as a material for monuments and gravestones also, and our oldest cemeteries contain many examples of it.

Quarries for marketing stone are worked at Paterson, Little Falls, Belleville, Newark, Orange, Washington Valley, Martinville, Princeton, Greensburg and Prallsville. The largest of these are the Belleville and Newark quarries on the east, and the Greensburg quarries on the west, side of the State. The others do more at supplying local or special demands.

PALISADE MOUNTAIN, BERGEN HILL.—Quarries for getting small supplies of stone to meet occasional local demands have been opened at several places along the western foot of Palisade mountain, in Bergen and Hudson counties. And good stone have been obtained at Alpine, near Englewood, Homestead station, and at Saltersville near Bayonne, and possibly at other points. The sandstone underlying the trap rock on the Palisades front, is generally too coarse-grained and too crumbling to be of much value as a building stone. It can be seen at Weehawken, and thence along the base of the cliff to Closter, and quite to the New York line. Near Englewood and northward to Tenafly the loose stone has been used to good advantage in several buildings in these places. It would be desirable to find a quarry in the solid ledges, of such stone. Near New Durham, the New York, Ontario and Western railroad cuts into a very pretty, light-colored sandstone, which should be further opened, as it is promising in appearance and is conveniently located for transportation. But there are doubtless other localities which might be tested, with fair chances of opening quarries of good and handsome graystone. Some of the subordinate hills and ridges are more likely to have it in them, as, in the main mountain, trap rock is the mass. The belt of sandstone east of the Passaic, in southern Bergen and in Hudson counties, has not produced any quarries of extent, and the long cut at Arlington shows the rock to be mainly a fine-grained and rather argillaceous rock, and not adapted to make a good building stone. An opening has been made within two years, east of Arlington, in the bluff, by Richard Westlake, and a grayish, coarse-grained sandstone exposed. The opening is 100 feet long and 30 feet deep, and of this depth about 18 feet is a fair building stone. The stone has been used in Arlington for foundations and cellar walls.

BELLEVILLE.—The so-called Belleville quarries are at North Belleville, on the west bank of the Passaic river, and less than a quarter of a mile east of Avondale station of the Newark and Paterson railroad. The first opening here for stone was made more than a century ago. But the quarries have been vigorously worked only within the past 25 years—or, since 1857. They were reported in the "Geology of New Jersey," 1868, pp. 506–7. Their production has greatly increased since 1879, and last year (1881) there were 375 men employed in the quarries and in the adjoining yards dressing the stone. There are four separate parties at work, although but three distinct quarries, as Robison's and Philip's are practically one. The workings move in a general westward direction, extending from within a few rods of the river road into the gently rising ridge. All of them descend below the tide level in the river. The overlying earth is glacial drift, containing much red sandstone, and in places imbedded sands and gravels. The strata of rock near the surface are generally much broken up, and yield small-sized stone only; as they are followed down the beds become more solid and of better quality. The descent or dip of the strata is towards the northwest, and at an angle of 10° to 12°. One of the most interesting geological features is a fault, which can be traced across Joyce's, Robison's and Philip's quarries. It is beautifully exposed in Robison's, where the displacement amounts to five feet, and its dip is 65° to 70° degrees westerly. Its general course is north and south, or, more accurately, south 3° east (magnetic). The west side appears to have slipped down, as the corresponding beds on either side of it would indicate.

In working, all of the quarries move with the dip, and hence stone have to be raised up out of their beds. There is no advantage of gravity. The stone are hauled by teams to wharves on the river, whence they are loaded and shipped by boats to points of destination. Blocks of great size are quarried out, and larger than can be conveniently handled. The United States census schedule returns from these quarries reported an aggregate product of 45,000 cubic yards, valued at $225,000. That was for the last half of 1879 and first half of 1880. The product for 1881 no doubt exceeded this total very considerably in value. The *Belleville stone* commands a wide market and brings good prices. The light-colored, grayish stone sells at $1.00 per cubic foot; the fine-grained, reddish stone, suitable for rubbing, brings $1.50 a foot. The new Mills building, corner of Broad street and Exchange Place, New York city, has absorbed a large amount of stone quarried during the past year.

Beginning at the south, the first quarry is that of Wm. J. Joyce. The excavated area exceeds two acres, and has an average depth of 60 feet. This quarry has been worked rather more into the hill or ridge than the others, and, at the present *heading*, is about 90 feet deep. The drift earth at the southwest side includes a number of thin layers of sand and gravel imbedded in the glacial unsorted mass. The phenomena of glacier action are plain in the glaciated ledges of sandstone, the striated and large bowlders and the heterogeneous mixture of earth-pebbles and bowlders. The thickness of this drift earth is, at most, 20 feet. On the west side there is about 30 feet of red, fine-grained sandstone strata, which furnish considerable stone for foundations, walls, &c. As followed down they will, no doubt, become more solid and improve in quality. Under them there is the grayish sandstone in thick beds. At the bottom a finer-grained and reddish-colored stone is obtained, which can be rubbed and polished. The joints in this quarry run vertically, west and north. As the beds are very thick, stone of the largest size required can be quarried here. Blocks containing 1,000 cubic feet have been broken out. Three steam derricks are used and a steam pump, all worked by one 50-horse-power engine. Stone of this quarry are to be seen in Fort Lafayette, New York harbor; Duncan & Sherman's banking house, New York; the new Mills building in Broad street, New York city; Garden City Cathedral, besides many others.

J. B. I. Robison's quarry is 300 feet north and northeast of that of Joyce. It constitutes, with the Philip's quarry, one opening, which is about 500 feet square in its extreme dimensions. The average depth is 50 feet. The dip of the beds is 11°, north 45° west, and there is a well marked system of joints running vertical, south 85° west. The other is not continuous throughout. The stripping varies considerably in the thickness; on the south side the beds are solid quite to the drift, whereas, at the west they are more broken up. Excepting one layer which is three feet thick, there is no good building stone to be had in the 60 feet from the surface down. Under it, however, there is 20 feet of thick-bedded stone, the lower half of which is fine-grained and of superior quality for rubbing, and brings a high price. On the south the stripping does not exceed 20 feet. The strike of the strata in these quarries seems to prove that they are the same, that is, the quarries of Joyce and of Robison are working the same beds, although Mr. Robison thinks that he is working in a lower horizon. He reports also having sunk 14 feet beneath the bottom of his quarry, or 49 feet below tide level, through shaly beds only, without finding any solid rock. Two engines are employed to work derricks and do the pumping. As in the other quarries, blocks of large size are broken out and then cut up into the desired forms for market. This quarry has deen vigorously worked during the past year, and a great amount of stone has been taken out. Newark, New York and Brooklyn are the principal markets.

The quarry of A. Philip & Son, as already mentioned, is in the same opening as that of Robison, adjoining the latter on the north; and south of the Bloomfield road. The average thickness of the glacial drift is 10 feet. Then there is about 10 feet of shaly beds, making a total of 20 feet of stripping. The dip is 10° to northwest. One main joint has a course south, 85° west, vertical. There is at the west end a fine-grained, chocolate-colored stone; further east the stone is of a grayish shade, and varies from a coarse-granular to a fine-granular variety. As in the other quarries here the gray stone contains fine grains of a whitish feldspar, distributed sparingly among the quartz. The mixture has a pleasing appearance, and the stone dresses easily and true. The fine-grained red variety can be rubbed. The strata worked by the Messrs. Philip are above those opened by Robison. One steam derrick is in use and two steam pumps, as there is a great deal of water issuing from the rocks at the west end. The stone for foundation walls sells at 25 cents per cubic foot. From that the price ranges upwards to $1.50 and $2.00 for the finer grades, suitable for monumental work, and which can be polished.

In all of these quarries *malachite* occurs near the east end and near the outcrop of the beds, in thin seams lying between the strata. Bituminous coal, in thin layers, is also found; and coaly stems and impressions of leaves and trunks are occasionally found. Messrs. Robison and Joyce both report finding large stems several inches in diameter. North of the Bloomfield road, and but a few rods from

Philip's quarry, is the recently opened quarry of the Belleville Stone Company. Work was begun here last summer, and a great deal of work was done during the season in uncovering and stripping the upper inferior stone from the more solid and merchantable stone, as is found in the other quarries. The prospects are good, and the company is pushing the work in developing their property.

The strike of the rocks and the range of hills, and the course of the Passaic river, appear to indicate that the Belleville stone belongs lower in this formation than that opened in the Newark quarries. It is east of the Newark strike or course, as prolonged. The relations to the Passaic seem to show the same.

NEWARK.—There are four stone quarries in this city, all of which have been in operation for a part of the year at least. They are all close together, on the crest of the ridge west of Fifth avenue, and near Bloomfield avenue. They are conveniently located, being within less than half a mile from the Passaic river, and the Erie, and Delaware, Lackawanna and Western Railroad stations, and only one mile from the Pennsylvania and Central depots. They are all favored by comparatively light stripping, little water, and a good thickness of excellent stone. The pleasing shades of color, evenness of grain, and durability, as shown in old buildings in all of our cities, attest its value, and it commands a ready market. The rapidly increasing value of the land for building purposes, and the unsightliness of quarries in cities, will eventually compel them to give way for the advancing city. The total product of these quarries is estimated to be worth $120,000 for the year 1881. The cities of Newark and New York are the principal markets, but stone are also sent to Albany, New Haven, Princeton, and the surrounding country towns.

The quarry on the south of the avenue is worked by the Newark Quarry Company. It is one of the oldest in the State, having been opened more than 70 years. The working face, running from north to south, is about 400 feet long. The quarrying moves westerly and southerly, and the stripping is used now to fill the excavated area on the east, as all this ground is valuable for building sites. The stripping varies from 10 to 30 feet thick. It appears to be rather less at the southwest, and work is pushed in that direction. The order of the stratification in the west face of the quarry is approximately as follows:

1.	Glacial drift	12 feet.
2.	Shaly rock, here termed "Callous." (In this there are some workable strata.)	15 feet.
3.	Shaly beds	1 to 4 feet.
4.	Dark-colored red sandstone	6 feet.
5.	" " (varying in thickness)	1 foot.
6.	Light-colored sandstone in thick beds	8 to 15 feet.
7.	"Callous" (very thin)	
8.	Dark-colored and harder stone	4 to 6 feet.

The dip is 5°, north 65° west. The joints are very irregular and no general direction is apparent in them. The stone of "6," in the section as given above, is most largely quarried. The bottom rock is less used. Very little powder is used in quarrying, and that in blowing down the top or stripping. Large-sized blocks are obtained by wedging off, following the planes of joints and of bedding. A small steam pump, working a part of the time only, raises the water. A larger engine works the two derricks for hoisting, &c. The working force, the past year, has been large, and a great quantity of stone has been quarried. The average price is about 70 cents per cubic foot. Newark and New York are the principal markets, although stone is sold at New Haven, Princeton, Albany and other cities.

Kocher Brothers' quarry is across the block, southwest of the last described, and is between 5th and 6th avenues and Ridge and Parker streets. It was opened in 1872. The opening is an almost square pit, about 200 feet on a side and about 50 feet deep. The glacial drift is here 10 to 30 feet thick, resting upon the solid strata of stone. The beds are thick and dip at an angle of a few degrees only towards the northwest. In the principal system the joints are remarkably clean and regular and traverse the mass in a northeast direction. The stone is of a light gray color and is more solid and harder than that of the other quarries generally. Some strata are a little reedy; but much of this stone shows no lamination or signs of bedding. The total thickness of stone quarried amounts to 30 feet, and goes down to shaly beds at the bottom. Very large blocks can be quarried here—30 feet long and three to four feet thick. Steam derricks are employed in hoisting, worked by a ten-horse-power engine. There is no water to be pumped out. Most of the stone is shipped in the rough, and brings an average price of 80 cents per cubic foot.

Righter's quarry, worked by Philip Höehnle, is on the northeast side of Bloomfield avenue, and northeast of that of the Newark Quarry Company. The quarry is old, and the area worked over must be about 700 feet long and 300 feet broad. The excavated contents is estimated to be 300,000 cubic yards. The deepest place is down 60 feet. A large area of stone on west side of the quarry has been uncovered recently. The approximate figures of the vertical sections on north side are:

1. Glacial drift	15 feet.
2. Stone, in thick beds	12 feet.
3. Shaly beds	3 feet.
4. Thick-bedded strata	12 feet.

This quarry has not been worked to its full capacity the past year. Several years ago it was worked by Robert Matches, and paid a handsome royalty for ten years, yielding a large amount of stone. William A. Righter, of Newark, is the owner.

W. D. Patterson's quarry was quite recently opened. It is on the north side of Bloomfield avenue, a few rods west of Righter's quarry. As yet it is in the nature of prospecting. And the excavation is only about 50 feet square and 40 feet deep. The glacial drift earth is five to eight feet thick. Then come shaly beds with some red sandstone—10 to 15 feet thick; next below is a drab-colored stone 12 feet thick. The dip is 8°, north 60° west. The stone is uniform in texture, fine grained and of a good color.

LITTLE FALLS, PASSAIC COUNTY.—The quarries along the river, below the village of Little Falls, are owned by Robert Beatty, of that place. Those on the west, or left bank of the stream, have been idle for many years. The main quarry, on the east or southeast of the stream, and near the village, is the largest and the most noted for its former activity and its excellent and beautiful stone. It was opened in 1840, and was worked until 1857, then idle until in the spring of 1880, since which time it has been vigorously worked by J. C. & R. Stanley. The working extends at least a quarter of a mile along in the bluff, and at the broadest may be 300 feet back from the river. The quarrying advances in a general east and northeast direction, and opposite the direction of the dip. The older quarrying was further to the southwest, and near the village. At the present southwest working, the quarry rock is covered to a depth of 18 feet, by glacial drift earth; at the extreme northeast this earth is not more than 10 feet thick. The general direction of the dip is towards the northwest, and varies from 5° to 10°. Vertical joints at southwest course north 60° east, and north 10° east. A very clean and persistent joint at northeast end of the quarry runs, vertical, south 70° west; and another at about right angles to it is not not always plain.

This quarry produces three principal grades of stone. That found at the southwest is known as the light brown stone; the middle of the quarry yields a harder, but very fine-grained, rich dark-brown stone, which takes a good polish and is noted for its adaptation to fine, ornamental work. It has been used for some of the interior decoration of the State Capitol at Albany. At the extreme northeast end, the stone is rather coarse-grained, and of a light gray shade. It occurs in thick beds, although there is not so much exposed as of the other grades. It was very recently employed in the chapel of the Madison Avenue and Sixty-sixth Street Church, New York.

In this gray stone, there are, in certain horizons, very fine impressions of plants, stems and leaves, and thin coaly seams, two to three inches broad. One of them was seen which had a length of eight feet. Ripple marks, very plain and well defined, are quite common on the red stone near the middle of the quarry. The locality is, geologically, of much interest, and needs further examination of its fossil stems.

In general, the stone of this quarry is remarkable for its homogeneity, its texture and its rich shade of color. Its durability has been tested in many public buildings, among which the more prominent are, Trinity Church and Trinity Chapel and Phœnix Bank, in New York City, U. S. Custom House and Post Office Building and the Essex County Court House, in Newark. The finest grades of stone answer for sculpture. Blocks containing 600 cubic feet have been quarried recently and loaded on the canal. Prices range from $1.00 to $2.50 per cubic foot. At present, 40 men are employed; and a large amount of stone was quarried during the past year. The accessibility to the Morris canal and the two railroad lines crossing the village, less than one mile distant, afford facilities for easy shipment, and a prosperous future seems to lie before this noted quarry.

ORANGE.—The quarries in the eastern face of the First mountain (Watchung mountains), west of Orange, are worked by James Bell, of that place. The present quarry is south of the earlier ones opened here, and about 200 yards from the turnpike. It was opened in 1880. The excavated area already measures 300 feet by 75 feet, and at the back is 40 feet deep. The dip of the strata is about 15°, west-northwest. The joints run north and south and east and west. There is a fault traversing the quarry lengthwise, from north to south, and dipping steeply to the east. The amount of displacement is only a few feet. The stripping consists of about 10 feet of earth, then shaly beds—in all nearly 30 feet. The total thickness of the quarry beds is 14 feet. This stone is of a reddish color, and uniformly coarse-grained, but it cannot be rubbed; it, however, dresses smooth. The quarry is so situated that there is no water to interfere with working, and it is close to the Telford road, and down grade to Orange, where nearly all of the stone is used. Prices range from five cents a cubic foot for foundation stone to ninety cents for cut stone, as sills, &c. The quarry is in operation constantly, and the product is large.

PATERSON.—There are three quarries worked in the eastern face of the First mountain, at Paterson. The southernmost of them is that of William P. Hartley. It was opened in 1848, and has been worked steadily since that time. The sandstone is seen here in contact with the trap rock overlying it, and together they rise in a vertical wall over 150 feet high. About 70 feet of this is sandstone and some interstratified beds of shale. The dip is 7°–10° towards the west-northwest. The beds of sandstone are very thick, and large blocks can be quarried. The workable thickness of stone is nearly 50 feet, in three or four strata, which are separated by shale. Some of the upper beds afford an inferior grade of stone, adapted to building of walls, foundations, &c. There are two principal grades of stone, one a light and the other a dark brown. The light-colored stone is used for cut work, for house trimmings and for fronts generally. It comes from the bottom beds. The dark-red stone is used for common work only. Prices range from twenty-five to eighty cents per cubic foot, according to quality.

The drainage is natural. One derrick, otherwise no machinery is used.

Samuel Pope's quarries are a few rods north of that of Hartley, and in the face of the mountain. They were opened in 1858. They are not worked back so far into the hill as Hartley's, and the trap rock has not yet been reached. The southern quarry is worked by Francis Devlin; the northern one is leased by James Kays; and both of them have been but recently started, after having been idle for several years. The beds opened in these two quarries are lower than those exposed by Hartley's, and the stone is more reddish, and some of the beds are conglomerate. Very little *cut stone* is obtained by Devlin; the greater part of it is sold in Paterson and in the neighborhood for foundations, cellar walls and rough work.

The stone from these quarries is mainly used in Paterson, and the stone mills, walls, churches and other buildings are mostly built of it. The advantages of perfect drainage, of a great thickness of quarry material, and of accessibility to a canal and to three lines of railroad, are notable points in their favor. The thickness of stripping, which in the case of Hartley's quarry is a mountain of trap rock, is a formidable obstacle, unless the stone can be got out by a system of underground mining, whereby the rock could be left as a roof and all the stone removed would be saleable. The practicability of working on a large scale in this manner is worthy of some consideration, especially as the quality of the stone is likely to improve under the trap rock.

HALEDON.—A quarry was opened several years ago in the eastern face of the Second mountain range, about a mile north-northwest of Haledon and three miles northwest of Paterson. It was idle for several years until 1880, since which time it has been worked at intervals, and the stone has been used in Paterson. It is a fine-grained, soft, buff-colored stone, resembling some of the Ohio sandstones; and it is said to dress readily and to be durable. The quarry is owned by Samuel Pope, of Paterson.

PLEASANT VALLEY, ESSEX COUNTY.—This locality is between the First and Second mountain ranges, and two miles south of Verona. The quarry here in the face of the Second mountain is owned and worked by F. W. Shrump. It was opened in 1871, and it has been in operation most of the time since, and nearly two acres have been worked over. At the northwest it is 55 feet deep. At the top there is a sandy earth and then a shaly rock, in all 12 to 16 feet thick, which has to be removed to get at workable beds. These are a grayish colored, rather coarse-grained stone, in thick beds. And under them there is 10 feet of red, fine-grained sandstone, suitable for rubbing and polishing. The same rock is in the bottom level where the quarrying stops, and the same kind of rock is reported to have been met with in sinking a well 35 feet lower at the house a few rods east of the quarry. The dip is 10° westerly; the joints are clean, and one system, very regular and continuous, runs vertical, south 70° west; the other, at right angle to it, and also vertical, is not continuous throughout. By means of these divisional planes, or *backs* and *headers*, the stone is quarried easily, and large-sized blocks are obtained. Blocks 30 feet by 11½ feet by 10 feet have been broken apart, and stone 12 feet 6 inches by 8 feet 6 inches by 2 feet 8 inches have been removed. The stone of this quarry resembles that of Little Falls, and it is in the same geological horizon as related to the Second mountain trap rock. The top gray stone contains some feldspar in small, granular masses. At the top the more shaly sandstone is micaceous. The quarrying moves southward and westward into the hill. An underground drain carries off the water. The hoisting and loading is done by means of a derrick, which is worked by a 10-horse-power engine. The stone are carted to the Morris canal, two and a half miles distant, and to the railroad at Orange or Montclair, points about equally distant. New York is the principal market, although much stone has been put into churches and other buildings in Orange. The Caldwell Presbyterian Church, the Reformed Church and Grace Protestant Episcopal Church, in Orange, are built of this stone. The product the last two or three years has been very large, and the prices range from 10 cents to $1.25 per cubic foot, according to the quality of the stone. On adjoining property, north of Shrump's, a quarry is being opened. It is not yet deep enough to reach good stone.

WASHINGTON VALLEY.—A full notice of this quarry appeared in the "Geology of New Jersey," 1868, p. 509. It was idle for several years, but it has been worked a part of the present season by its owner, Alfred Berry, of Plainfield. It is about 75 yards long, 40 yards wide and of an average depth of 30 feet. The strata dip 10°, north 30° west. One main system of joints runs (vertical) south 30° west. At west end of opening the planes of joints dip 65°, north 70° west, and 50°, south 70° east, and divide the rock into rhomboidal blocks. At west end the upper beds are shaly and of reddish color; then there is a yellowish buff-colored stone, thick-bedded, into which the quarrying has gone 18 feet in depth. At the opposite end there is opened 10 feet of buff-colored stone under 12 feet of earth and shaly beds. The pleasing tint of color and the homogeneous, fine-grained nature of this stone make it a desirable building stone, and it looks well. The First Baptist Church of Plainfield is built of it.

The drainage is by an underground adit, to within six feet of present working bottom. There is one derrick for hoisting and loading stone at the quarry. The cartage is over an excellent road, three miles to railroad at Plainfield. The ease with which the place can be worked, and the unique shade of color and general excellence of the stone, ought to make a market for it beyond what it has now.

MARTINVILLE.—There are three quarries at Martinville. The most eastern of them is no longer in operation. James Kipsey's quarry is south of the village. It supplies stone for foundations and cellar walls in the neighborhood. Stone is of a reddish color and fine-grained. There is a little light gray at bottom of the quarry. Only two men are employed, and the product is small. It was opened about 50 years ago.

The quarry of Messrs. Bartle & Brother is the westernmost opening in this part of the valley. It is south-southwest of Martinville. At least three-fourths of an acre has been worked over to an average depth of 35 feet. The quarrying follows somewhat the dip of the rock to north-northeast. The joints are open and run vertically nearly north and west. The stripping is a red, shaly earth and sandstone, and is 15 to 20 feet thick. Some of the stone in it can be used for foundations and for common uses. The *quarry stone* is mostly of a light gray color, and there is a thickness of 11 feet of it in the whole 20 feet worked. This grade is very fine-grained and soft, and is easily dressed. It is worked into cut stone for sills, lintels, steps, water-tables, &c. The common grade of red stone brings $1.25 per cubic yard; the cut stone sells at 70 cents per lineal foot, or running measure. Near the top the thinner beds yield stone which answers for flagging. They are from one inch to six inches thick, and can be got out 11 feet long. The principal markets for this stone are the towns of Plainfield, Somerville and Bound Brook, and a little is sent to Brooklyn. The nearest railroad and canal lines are at Bound Brook, four miles away.

The quarry has been worked briskly during the past twelve years, or since it was opened, and it is equipped with all the machinery to do a large business. A 20-horse-power engine drives the two pumps and two gang saws. Two derricks at the quarry, besides four additional ones at stations, facilitate the loading of stone.

PLUCKAMIN.—The quarry east of the village is no longer worked.

The quarries at *Millington, Basking Ridge* and *New Providence* are very rarely worked, and then for local demands only.

The quarries along the Raritan river, at *Five-Mile Lock* and *New Brunswick,* have ceased to yield stone enough to warrant their retention in a list of our quarries.

At Davison's Mill, on Lawrence's brook, there is an abundance of altered shale, which breaks up in rectangular blocks and furnishes a durable building material. It has been worked to some extent, and would be valuable if transportation were convenient.

KINGSTON.—The canal company's quarry at this place is kept steadily going for the supply of stone for slope walls. The stone is not adapted to fine work.

PRINCETON.—Stephen Margerum's quarry is east of Princeton, about one mile from the railroad station. The excavation covers an area of about an acre in extent. It was opened in 1845. It is worked for local demand only. The stone is of a bluish shade, and properly an indurated argillaceous sandstone. The strata dip gently to the northwest. The average depth of the top dirt is about four feet, and the mean depth of the quarry is 12 feet. Stone 20 feet by 10 feet and 6 inches thick have been quarried. It is used principally for buildings. A little is laid as a flagging stone in the streets of Princeton. The production varies greatly, according to the demands of the neighborhood.

Thomas Jewell's quarry is near the canal, southeast of Princeton about one mile. The strata dip about 10° toward the north-northwest. At the top the beds are shaly. The best stone is very solid and quite hard, and of a grayish color. The stone has been used in the construction of some of the Theological Seminary and the College buildings. The quarry was opened in 1800. It is worked steadily, but not very extensively—for local demands mainly. The stripping is about four feet thick. Drainage is natural. Being so near the Delaware and Raritan Canal, it has good facilities for reaching the largest markets.

GREENSBURG.—There are four quarries at this place. All of them are on the east side of the feeder of the Delaware and Raritan Canal, and close to it, and also to the Belvidere Delaware Railroad.

They are conveniently located for easy working and for shipment of their stone. The towns along the Delaware river and Philadelphia are their markets. The stone is known as "Greensburg stone," or as "Trenton brown stone." Their aggregate product in 1873 was estimated to be 60,000 tons, valued at $90,000. The statistics for the census year furnished to the United States Census Office recently, amounted to 22,000 cubic yards, valued at $36,000.

Beginning at the south, the quarries are:

1. Chas. Keeler & Son.
2. Greensburg Granite and Freestone Company.
3. L Clark & Bro.
4. James Green.

The quarry of Chas. Keeler & Son was opened in 1833. It was formerly Hill's, and was described in the "Geology of New Jersey," 1868, page 510, under that name. The excavation is much larger than it was at that time—being about 700 feet long, on the canal bank, and about 300 feet from the canal eastward. The strata opened show a gentle inclination or dip of 10° towards the north-northwest. The joints are vertical and their courses vary from a few degrees west of north to west. The rock varies from a red, argillaceous sandstone, in some of the beds, to a grayish, feldspathic conglomerate. The beds within ten feet of the surface are apt to be friable and somewhat disintegrated. Followed down, they are firm enough for quarry stone. Some of the more shaly rock is, however, at the bottom of the quarry, of an inferior character. The alternation of strata is illustrated by the following vertical section, observed at a visit some months ago:

1. Yellow, sandy loam	4 feet.
2. Red, shaly rock	5 feet.
3. Gray sandstone	12 feet.
4. Shaly beds	4 feet.
5. Reddish gray sandstone	15 feet.

Of these Nos. 3 and 5 were worked for building stone. That of (3) dresses finely.

On the north side of the quarry the shaly beds (2) were thicker; as was also the gray stone (3), but these figures are somewhat modified by working and opening further upon the strata. At the southwest the gray stone near the surface is soft and crumbling. The conglomerate contains small white-quartz pebbles. In some of it there are quite large red-shale pebbles. Much of the gray sandstone is a coarse-grained mixture of white quartz and a whitish feldspar, with an occasional pebble of white quartz.

The blocks of stone are wedged off as far as possible without using any explosives, and are loaded by means of two derricks on the canal bank, directly on to boats. The stone is sold according to quality and shape, as *monumental rock, dimension stone* for fine buildings, for heavy railroad work, and as common building stone.

The quarry of the Greensburg Granite and Freestone Company is on the canal feeder, directly opposite the Greensburg (railroad) station. It was formerly worked by J. C. Grant. There are shaly rocks, sandstone and conglomerate, as in the quarry of Keeler & Son, although the strata here are higher in the series—that is, they belong to a higher horizon than those of the latter quarry. The descent or dip of the beds is at about the same angle, 10° to 12° north-northwest. Vertical joints, running generally north and south, and nearly east and west, divide the rock into large, rectangular masses. And as in the other quarries here, they are followed in the quarrying, and the use of explosives is reduced to a minimum, excepting in throwing down the top, shaly rock or stripping. The thickness of top dirt and shaly materials varies from 10 to 20 feet. The total thickness of merchantable stone is nearly 30 feet, varying, however, in the different parts of the quarry. The conglomerate cropping out here shows pebbles of white, translucent quartz, also reddish quartz, up to an inch in length. Some of the beds contain long and flat pebbles of red, shaly rock. Micaceous sandstone is also seen in this quarry, generally in thin beds, which lie between the thick strata of gray, feldspathic stone. In the latter, here, as in the other Greensburg quarries, the quartz predominates, and the feldspar is conspicuous by its dull white appearance, as contrasted with the quartz, and by its occasional decomposition, causing the mixture to fall down as a coarse, sandy mass. The alternation of red, shaly beds and the gray, coarse-granular feldspathic sandstone, in thick beds, indicates a sudden change in the conditions at the time of their deposition.

Clark & Brother's quarry is a quarter mile northwest of the railroad station. Formerly it was known as Moore's quarry and was worked by Prior & Reeder. The property is still in the Moore estate. It was opened in 1843. The area uncovered and worked runs back, narrow, from the canal a distance of 400 yards. And at the further end it is 50 feet deep. Dip of beds is 10° to 12°, north 30° west. At the top there is 10 to 12 feet of red, shaly earth and shaly rock. The beds of workable stone are thick and a grayish-reddish feldspathic sandstone. Another smaller quarry, also belonging to the Moore estate, lies north of the main one. The stone in it is rather finer-grained.

James Green's quarries are near his residence, and from a quarter to half a mile from the Greensburg depot. One, the southernmost, is near the Moore property. The stripping is heavy and the stone is of a reddish shade. The total thickness of quarry beds is, however, as heavy as anywhere in the Greensburg quarries. The other quarry of Green is near his residence. An excavation made to get masons' sand led to its opening. Dip of strata is 10° to 15° northwesterly. The top earth and *rotten rock* does not exceed 10 feet in thickness; average is about five feet. The joints dip steeply to to south and to west. The quarry beds as opened in 1879 had an aggregate thickness of 35 feet. The stone is hard, but is said to dress well.

The general resemblance among the thick beds at the several Greensburg quarries, and the sharply defined shaly strata occurring with them, have suggested the possibility of faulting in the strata, giving rise to a recurrence of the same order in the several openings. But no evidences of faults have been found. And, besides, it is maintained by the quarrymen that the strata are distinct and unlike in working. A careful survey is necessary to settle the question.

The Greensburg stone, in general, dresses readily; it is of a pleasing shade of color, and its durability has been tested in many public edifices in Trenton, Philadelphia and elsewhere. Nearly all of the stone buildings in Trenton, and many elsewhere in the towns along the Delaware river, are of this stone. The stone is sold by the perch, at prices ranging from $1.00 to $6.00; also by the cubic foot and cubic yard. The finer grades bring 75 cents to $1.50 per cubic foot. Monumental stone sells at about $3.00 per cubic foot.

The comparatively light stripping and the inexpensive disposal of it, the thick beds of good stone, the ease with which it is dressed, the facilities for drainage and easy handling, the convenience to boat and rail, and the nearness to good markets, should conduce to increase the product of these quarries.

LAMBERTVILLE.—The blue, indurated shale, which occurs east of the town, in the bluff, and north of the Goat Hill trap rock, has been opened and a very little of it used here. It is a hard and rather brittle stone to dress. Further from the trap rock, northward, a red sandstone is obtained for local uses, for walls, foundations, &c.

STOCKTON.—Peter Best's quarry is in the village and not far from the railroad. There is little earth, then shaly strata at the top; then the thick-bedded, gray sandstone. In some of the strata there are red shale pebbles. Dip is towards the northwest, at a gentle inclination. This quarry is worked to a moderate extent.

At Brookville, about a mile east of the Stockton depot, a quarry was opened two years ago, which has been in operation a part of the time only. Dip is 20° to northwest. The rock is a grayish white sandstone, with a few scales of mica.

There is a small quarry at the east end of the village of Stockton, in a gray sandstone.

PRALLSVILLE.—The quarries at Prallsville are near the river road and the Belvidere Delaware Railroad, and at an average distance of one mile from the Stockton station. That worked by James Sillery has an average thickness of 15 feet of stripping. The dip, as usual in this region, is very uniform towards the northwest. The stone is a reddish-gray color, and is rather coarse-grained. The quarry has been worked actively, and the product finds a market in Philadelphia.

The Pennsylvania Railroad Company's quarry is west of the Wickcheoche creek nearly half a mile. The beds here are thick, and the stone is of a light gray shade. Thin strata of red, shaly sandstone occur on top of the quarry beds, and also at the bottom. Occasionally a small white-quartz pebble is seen in the gray stone. The quarry is worked for the use of the company, and the stone is liked for heavy railroad work, as piers, abutments, culverts, &c. The New Brunswick (railroad) bridge piers are mainly of this stone.

Near the mouth of the Wickcheoche creek there are two old quarries which have been idle for many years. Hoppock's quarry (east of the creek) was actively worked in 1867–73, and from it was obtained the stone for the piers of the Pennsylvania railroad bridge over the Schuylkill. Its product in 1873 was estimated at 18,300 perches. The stone is rather finer-grained and of a light gray to buff-colored. The dip is 20°, north 25° west. The gray stone is 18 to 20 feet thick, with red shaly rock at bottom of quarry. In the old quarry, on the west of the creek, there is more of the pebbly stone, or conglomerate. Thick beds lie on red shale here. The pebbles are mostly of white, opaque quartz and reddish quartz, although there are some of red shale and a few of blue calcareous rocks. They vary from one-quarter of an inch to one inch in length, and lie conformably to stratification. They appear to be very unequally distributed in the different beds.

The total production of these Stockton-Prallsville quarries appears to have declined considerably since 1873, when their aggregate was estimated to be 35,606 perches (of 25 cubic feet). The census year statistics are less than one-fourth of that estimate. The nearness to railroad and canal transportation, and the large size of the blocks which can be obtained in these quarries, and the conveniences in working, ought to stimulate their production and especially for stone for heavy work.

TRAP ROCK.

PAVING BLOCKS—ROAD MATERIALS.

Trap rock continues to be quarried at many places for road material, paving blocks and monumental bases, and occasionally for building purposes. The geological map indicates the areas underlaid by this rock.

Palisade Mountain.—The trap rock of this mountain is quarried at a large number of localities, principally about Guttenberg, Weehawken, West New York and along the Palisades south as far as Montgomery avenue, Jersey City. Cuttings for streets and railroads also furnish material which is used for roads and streets and railroad ballasting. The trap block quarries are generally small affairs, and gangs of two to five men work together in a quarry. It is common for the men to lease the properties and sell the stone to a contractor or dealer. The blocks are of two sizes; the larger are known as *specification blocks,* and are four inches by eight to ten inches on the head, and seven to eight inches deep; the *square blocks* are five to six inches square, and six or seven inches deep. The much greater use of the former size has caused the business to increase very much within a few years, and nearly all the blocks now made are of the larger size. They bring $30 per thousand, the square blocks sell at

$20. The product of the quarries on Bergen Hill and Palisade mountain is estimated by Michael Shannon, a large dealer and contractor in Jersey City, to be 4,000,000 of specification blocks and 1,000,000 square blocks, in 1881, valued at $140,000.

There are three principal grades of rocks—the fine-grained, which is quarried in Mount Pleasant, a rocky hill north of the Pennsylvania railroad; the light-gray variety, which is quarried south of the Pennsylvania Railroad line or Bergen Cut; and, third, the dark-colored variety, from near Weehawken and West New York. All of these varieties are hard, but they split readily into blocks. In some cases there is little waste. The larger-sized blocks are more difficult and expensive to get, and splitting them out is attended with more waste. But all of these clippings can be utilized in Telford road construction. There is a great difference in the splitting of the stone, as some cannot be worked profitably on account of imperfect *cleavage*. The quarrymen soon learn to detect these differences, and work such localities as furnish stone most profitably, making the greatest number of blocks with the least loss of material and labor.

The oblong size or *specification size* has been found to answer well in pavements, quite as good as granite, and the prospect is that the business will increase. The amount of material is inexhaustible, and is so accessible that it can be obtained as cheaply as any stone in the country. Its nearness, at the very doors of our great city, is another important item. The stone can be loaded at once and carted direct to the street to be paved.

Trap rock has been employed in building in Jersey City with very fair success in architectural effect. St. Patrick's Roman Catholic Church, in south Jersey City, is built of it, with granite trimmings. The stone is very dark-colored. It was quarried a few rods only from the church site. The Hudson County Court House is also of trap rock. The stone has a large use in walls, foundations, &c., on Bergen Hill, and in the neighborhood.

A large amount of this stone is employed in ballasting the railroad tracks. The Pennsylvania and Central Railroad Companies have used it very extensively, and the other lines which run through Bergen Hill also get it. The ease with which it is cracked, and its toughness and indestructibility, adapt it admirably for such use, and the convenience in getting it adds to the economy of its use for making an enduring, solid and dry road-bed. At New Durham, Abram W. Duryee has a quarry and a cracker, and he furnishes stone for Telford roads in the upper part of Hudson county.

ORANGE MOUNTAIN.—West of Orange, in the face of the First range of the Watchung mountains, trap rock is quarried extensively for road material by Geo. Spottiswoode, John O. Rourke and General John G. Wright. These three quarries have each a cracker for breaking up the stone, and they get out a large amount annually for the construction and repair of Telford roads, in Essex county. This stone makes the admirable roads of Essex county.

Trap rock is quarried extensively on the western side of *Snake Hill*, Hudson county, at *Morris Hill*, in Paterson, in the gap of the First mountain north of Plainfield, for the supply of road-making materials and street walks. The localities where it can be obtained are many, as, nearly everywhere where this rock forms the underlying formation, it is accessible with little uncovering, and in very many places it crops out in bold ledges which are conveniently reached. The rapidly increasing population of the northeastern section of the State, with its many towns and cities, have this rock near them, as a most convenient and inexhaustible source of valuable material for making excellent roads and walks. And its use should be encouraged and increased. There is no better rock for such uses.

On the western side of the State, trap rock is not so abundant or so widely distributed. It continues to be quarried at Rocky Hill, by M. A. Howell, of New Brunswick, who prepares paving blocks and Telford road material, and also finer stone for walks. This quarry is convenient to canal and railroad.

Along the Delaware river this rock has been quarried to some extent, near Titusville, Smith's Hill, and near Lambertville, in Goat Hill. At the latter place an immense number of large blocks lying loose on the steep mountain declivity have been thrown down and worked into blocks. The solid ledges also have been blasted, and stone can be got here very conveniently and cheaply. The stone appears to be very uniform in composition, and is more solid as it is opened more in the hill. And the latter breaks better for blocks. The sizes cut are 10½ by 3½ inches on the head instead of the 8-inch cubes as formerly sold. The oblong shape is much preferred. There are two firms at work here, Geo. Banchoff and Wm. Bainbridge. Their markets are principally Trenton, Camden and Philadelphia. They do a large and good business.

Stone for monumental purposes, and also for house trimmings, is quarried at Rock Church, four miles from Lambertville, by Jas. H. Murphy, of Flemington. The quarry is in the loose blocks on the surface, and not in the solid ledges. These blocks are very large. One of them, which has been partly worked up, was 50 feet long. The stone is of a dark shade and splits readily by plug and feather, and polishes well. Mr. Murphy has used it with great success in bases and in monuments, and also for sills and window caps. For monumental work it is liked, and is used by him to supply a large trade. It is known in trade as a *granite*. He says that it is equal to the best granite in the market. Its strength, durability and beauty commend it. This stone has been employed very recently in the new Deats brick building in Flemington, for trimmings. The fine tracery work in the caps looks well. There appears to be a new field for capital and energy in developing this beautiful stone. And the success already gained is a warrant for further work and suggests other localities, possibly, in the extensive area of our trap rocks.

FLAGGING STONE.

J. L. Burroughs & Son.—This quarry is one mile south of Woodsville, and in Hopewell township. The strata are shaly near the surface, and a blue, fine-grained, thin-bedded slate rock below. The quarrying has gone down a depth of about 40 feet, and an area several rods square has been worked over. The older workings were to the east of the present quarry. The bedding is very regular; thin beds alternating with thicker; and the dip is 20°, north 40° west. The surfaces are generally very smooth, and little dressing is necessary. Stone are quarried 16 feet by 8 feet 6 inches, and 12 feet by 8 feet have been shipped from the quarry. Blocks 40 by 20 feet and 16 inches thick have been uncovered. The stone is used mostly for sidewalks, but some is sold for bridge abutments, for cellar bottoms or floors. It is carted to Trenton, Flemington and Lambertville, and into the neighboring country. A little is shipped by rail from Moore's station, on Delaware and Bound Brook railroad, which is one and a half miles distant. Prices vary from 10 to 30 cents per square foot, according to size of stone. The quarry is worked in connection with the farm, and the production annually is small. During the past year five men were employed a part of the time, and the quarrying has been mostly in getting out stone, with but little stripping. Two derricks at the quarry and one at the station are all the machinery in use. The drainage is natural. As the stripping is only about 12 feet thick, the expenses of working are not large.

MILFORD, HUNTERDON COUNTY.—Flagging stone has been quarried at several places within one mile of Milford. The Robbins & McGuire quarry is west of the Spring Mills road, north of the town. It has been idle for some months. Across the creek and on the east of the road, Smith Clark's quarry is opened in the hillside. Dip of beds is to northwest, and the stone resembles that of the other or eastern quarry worked by Clark. One of the slabs seen in place two years ago showed indistinct markings of what appeared to be footprints.

The old quarry of this vicinity is north-northeast of the town, nearer the Little York road. Some thin conglomerate beds occur here interbedded with the grit or flagstone strata; and the same strata, when followed down towards the creek, are less gritty and more of a reddish color. The conglomerates contain a considerable percentage of blue limestone pebbles. The general dip is, on the average, 20°, and towards the northwest. The gray, flagging stone beds appear to be of limited extent, as in the river bluff, but a short distance to the west and southwest nothing is seen of them. The upper strata at Clark's quarry are thin, and occasionally pyrite crystals occur in them. Impressions of stems and of needle-like leaves are common in certain beds. The thickness of the stripping is about 20 feet. The stone are smooth and of good size, although not so large as can be obtained in the Hudson river quarries. The product is small and is mainly used in the neighborhood.

FLAGSTONE HILL, SUSSEX COUNTY.—There are four quarries opened on this high slate ridge. S. Dennis' quarry is on the northern foot. It was opened six years ago. It has not been worked steadily. Moses Fuller's quarry is on the eastern side of the hill. It also has been idle for some time. The Carr quarries are on the northward slope, but near the top of the ridge. The locations occupied by Asa and George Carr were first opened in 1801, for hearth stones and for walks about the homestead. As a *quarry*, work began in 1859, and since that time the work has gone on with little interruption. The main quarry is 400 feet long and 70 feet wide, and has an average depth of 6 to 10 feet. The *stripping* consists of earth and thin, shaly strata, in all from 2 to 5 feet thick. The strata dip 5° to 6°, north 35° east. The very regular and open joints are nearly vertical, and run north 28° east, and south 85° east. The planes of joints dip very steeply to north and to east-southeast. The joints are very true and open. The *lifts*, or quarry beds, vary from 1½ inches to 10 inches in thickness. One block measures 74 feet by 14 feet, and stone 60 feet by 14 feet, and 10 inches thick, can be broken out. The only limit in size is that which can be handled and carted away. The surfaces of the heavy stone are generally very true and smooth, and need very little hammering to scale off any roughness. Some of the top lifts are rough, resembling indistinct ripple marks. The thinner beds predominate, and these are the great resources of the quarry, as they are preferred for the country trade. In places near the top the strata show some signs of weathering in the brownish shade of colors. At the bottom of the quarry the rock is a true slate, and shows cleavage plainly. The flagstone of this quarry is of a dark blue or slate color. The grain is very fine and close. No fossils have been found in the rock at any of these quarries, so far as could be learned. From the location it is highly probable that the rocks are a part of the Hudson river slate formation. Thomas Carr's quarry is within 100 yards of the above-mentioned, and also on the northern declivity of the ridge. It was opened by a company about 10 years ago. The area worked over is about 100 feet square and 6 feet deep. An anticlinal axis descending northward runs through the quarry, making the dip on the west to north, or few degrees west of north, while on the east it is to northeast. This quarry is worked to a very moderate extent only.

These quarries sell most of their product to the surrounding country, as far as Middletown, New York, and Newton. Some stone have been carted as far as Belvidere. The New York, Ontario and Western railroad is 1½ miles distant, by a good, down-grade road. Formerly, when worked by the Middletown company, a large quantity was sold in Paterson and some in Jersey City, and west as far as Port Jervis. The prices are on the average 10 to 15 cents per square foot, according to the thickness of the flags.

On account of the slight amount of stripping to be removed, the perfect drainage and the large size of the slabs, the quarrying is cheaply done, and the locality can be worked profitably. The supply seems to be practically inexhaustible, as the whole ridge appears to be capped by it. The railroad facilities are good. The product is said to have been formerly between 40,000 and 50,000 square feet in a year. It is much less at present, as no effort is made to extend the business beyond the supply of the neighboring villages and country. It should be largely increased.

SLATE.

The slate quarries at Lafayette and Newton, in Sussex county, have been in operation a part of the year. The Delaware Water Gap quarry has been temporarily idle. But it is reported that work will be resumed as soon as the new railroad—the extension of the New York, Ontario and Western—is done through the Gap. This road will give it facilities for shipping greatly in advance of the old way of crossing the river or carting to the Water Gap Slate Works.

The production of our slate quarries, during the census year, amounted to $10,000, and they employed 25 men, but this was less than in former years, as two of the quarries were not at work. With the increased railroad facilities near all of our quarries, and the resumption of work at the Water Gap, there is no reason to suppose that this product will not be more than doubled during the coming year. The durability of our slate and its good color fit it for roofing material. The manufacture of school slates, of tiles, mantels and other ornamental shapes may be established, also.

The opening of new localities is attended with heavy expense, and more is to be hoped for in or near the present quarries than in new ones, although the slate formation occupies more than half the area of the Kittatinny valley.

BROWN SANDSTONE AND CONGLOMERATE.

Brown sandstone and conglomerate, consisting of sand and gravel cemented together by oxide of iron, are found in very many localities in the southern part of the State. They are not confined to any particular formation, but occur in all the strata of the Cretaceous and Tertiary formations. They are more common, however, in the red sand bed and in the sand bed capping the upper marl bed. The geographical distribution is equally wide, and there are few townships in which stone may not be found to some extent. The places where it can be obtained in quantities and where *quarries* are opened are comparatively few, inasmuch as the stone is only suitable for rough walls and foundations, and the demand for it is limited. The deposits appear to be of irregular form and are stratified only so far as the sand and gravel are in layers or are bedded. Often there are no signs of bedding. The false bedding and the various forms of structure seen in sand deposits are also seen in this stone. The color is generally some shade of red, yellowish brown to dark red. In some varieties the white-quartz pebbles are contrasted with the dark brown matrix of sand and iron oxide. The percentage of ferruginous matter varies greatly, and in some cases it approximates to a lean, brown iron ore.

From the fact that it occurs so commonly in the tops of the hills in the green-sand marl district, it has been supposed to be a distinct formation. And Prof. Henry D. Rogers, in his Geological Report in 1839, called it the Brown Sandstone Formation. Its occurrence, capping the hills and ridges, explains the existence of the hills, as it has resisted erosion. But these hills are mostly of the red-sand bed, and it is in this that the stone is found to the greatest extent.

In the southeastern part of the State there are many localities, but generally the masses are thin and often a single stratum only is found, and these running out in a few yards distance. Frequently the masses appear to be entirely detached and separate. In such cases there can be no regular quarries. The stone are found by probing in the sand with sharp-pointed rods of iron. Of course the work is all near the surface, as no deep excavation or pit can afford to be dug to get them. When found in a continuous layer or bed blocks of large size can be cut. Mr. Geo. Wood, president of "The Millville Manufacturing Company," at Millville, writes, "I know of one such layer found under about 20 feet of sand, from which were cut stones seven to eight feet in length, by four feet wide and three feet thick, but it is unusual to obtain them of such large dimensions." This stone can be squared and dressed, but not nicely or with profit. It is rarely used for other than foundation and cellar walls, and such common work. It has, however, been employed in a few cases in buildings, and looks quite well. The Episcopal Church, in Eatontown, in Monmouth county, and the West Jersey Academy, in Bridgeton, are examples of the use of this stone. The largest and heaviest stone of the kind are to be seen in the large dam at Mays Landing. The use is local, and cannot be otherwise than confined to the country in which it occurs. It is sold at $1.00 to $1.25 per load, or perch, at the quarries.

This brown sandstone is found near New Brunswick, in Middlesex county; in the Mount Pleasant range of hills, in Stone Hill, in the hills south of Eatontown, near Pyles Corner, and near Imlaystown, in Monmouth county; at Arneys Mount, in Burlington county; near Prospertown and near Waretown, in Ocean county; near Blackwoodtown, in Gloucester county; at Conrad, in Camden county; at Egg Harbor City, Mays Landing, Estellville and Weymouth, in Atlantic county; near Bridgeton, in Cumberland county, besides many other places. The above-mentioned localities are some of the most extensively worked and larger deposits. In the absence of any other stone, it is of considerable importance in the southern part of the State, and is a cheap and durable material for foundations, cellar walls, &c., and the aggregate use of it is large. It hardens on exposure, and on this account it makes an excellent road material, although not used for such purposes, except on very short outcrops, which chance to be crossed by roads.

VI.

CLAYS, BRICK AND POTTERY.

The localities where clays are dug or mined, their mode of occurrence and their uses, were fully reported in 1877 in the Report on Clays. In the last annual report the results of some fire tests were given, and the purity and high refractoriness of our clays were mentioned. It is perhaps too soon to expect much criticism or receive any verification in practice of the classification there made. The general excellence of our Middlesex county fire clays, and their capacity for resisting heat, are so high, that in practice there is no occasion to subject them to more severe tests, such as would bring out differences, and thereby confirm or upset this classification. In their great purity, their plasticity and their refractoriness are combined properties, such as are not common in clays in any other part of the world. It is not too much to say that, considering all the points of comparison, they are unsurpassed. They are widely used in nearly all the fire-brick works of the eastern United States, either alone or mixed with other clays. In the manufacture of white ware and the finer grades of pottery they are essential, to give plasticity to the non-plastic kaolin clays of Pennsylvania and Delaware. Of their purity, a recent letter from Dr. C. Bischof, of Wiesbaden, Germany, says: "Several of them are of such purity as is entirely unknown to us upon the Continent" (Europe). And he proposes to continue the work of testing the clays of our State by the side of European clays, as well as others from America.

The production continues large, and while most of the old localities are at work, there are discoveries made of new ones, where the beds are found at accessible depths. The map of the district is thereby tested, and it is found to be essentially correct in its indications. There has not been much done in opening the Raritan bed, excepting a pit on the Island farm, which has been opened by Terry Clancy. The clay from it is found to be adapted to white ware.

The brick-making business of our State is large and in a thrifty condition. The yards on the Raritan and South rivers, on the Raritan bay shore and on the Delaware, have their clays conveniently located, and the adaptation of these clays to the manufacture of brick of excellent quality, and their nearness to markets, give them advantages which enable them to work steadily, and the production is increasing year by year.

VII.

DRAINAGE.

The drainage works in the Great Meadows, on the Pequest, in Warren county, continue to fulfill their office very satisfactorily. The whole of the ground, both meadow and swamp, is provided with a sufficient outlet to carry off all the water that falls or is discharged upon it, without allowing any to overflow the surface. The land where cleared and cultivated proves to be of the first quality. Mr. Wm. Vreeland, of Danville, who has cleared a considerable tract for farming purposes, and has it well ditched and drained, has had some of his fields measured, and his crops ascertained by responsible parties, and they report the following:

17.07 acres in corn yielded 1,390$\frac{6}{56}$ bushels of shelled corn, being an average of 79$\frac{1}{56}$ bushels per acre. One acre, selected as the best, yielded 73$\frac{51}{56}$ bushels; which was an error in judgment of those making the selection. The acre selected as the best was one on which no manure had been applied, and the yield is an excellent one, but the result shows that those parts of the field which were manured yielded the heaviest corn. The corn crop was sold for $1,006.74.

13.95 acres of hay yielded 2$\frac{3}{4}$ tons per acre, which was sold for $840.

0.99 of an acre of onions yielded 600 bushels, which were sold for $600. A quarter acre selected from this field yielded 213 bushels.

The land on which these crops were grown I do not consider to be at all above, even if it is equal to, the average of the whole tract drained. There were several other good crops grown on these reclaimed lands by different farmers. All the crops grown the past season were much better than those on the surrounding high grounds; they were less injured by the severe drought, and it cost much less to till the ground and cultivate them.

The improving of this large tract of rich farming land is a great public benefit; and now that it is open to markets by a railroad which runs through its whole length, it ought to be immediately cleared, and put in condition for returning a profit to its owners.

The progress of its improvement has been delayed, and the cost of its drainage largely increased by the litigation set on foot by some of the largest land owners.

VIII.

WATER SUPPLY.

The question of a supply of pure, wholesome water is assuming greater importance with every passing year. The gathering of population in towns and cities is increasing the need for more copious supplies, at the same time that the accumulation of filth and impurities on the surface is contaminating the supplies from the wells, which in former times were the chief reliance. The numerous cases of malignant and fatal disease, which can be traced to the use of water from such wells, have created an uneasy feeling in the public mind. And the possibilities of poisoning from such cause is a well-founded reason for the inquiry propounded above. In all thickly-settled countries well-waters are unsafe, and the surface water running in brooks and small streams in cultivated countries is liable to become impure from the various matters used to enrich the soil. Deep-bored wells have been uncertain in their quantity or quality yielded. Some of them have yielded largely, others have failed entirely. Many of them have yielded water of bad quality, and others have materially changed quality and amount after they have yielded good water for a long time. The only resource then is the streams, springs and lakes, in some mountainous and thinly-settled district of country, where rocky, wooded and uncultivated soil occupies most of the surface, and where such a state of things is likely to continue. In that portion of New Jersey nearest to New York, there is a population of 300,000 people gathered in cities and towns, and nearly 200,000 more in a thickly-settled country. And this is likely to be doubled in the next 30 years. For all these the present sources of water supply are inadequate, and the quality of that which has to be used is exceptionable, and some of it dangerous.

The head-waters of the Passaic above Little Falls are sufficient to meet all the requirements of the district and of the population that has been spoken of, or a population five, or even ten, times that. That river drains an area of 750 square miles above Little Falls, and it is capable of supplying more than 400,000,000 gallons of water daily, if proper provision were made for storing that which now runs to waste in storms and freshets.

All the water from this great area is collected in a single stream only 100 feet wide at Little Falls, and it is there at an elevation of 150 feet above mean tide, and only 14 or 15 miles from the Hudson river at Jersey City. By going back a few miles farther into the mountains, streams of water can be secured which have never been where there could be a suspicion of any impurity, and reservoirs could be constructed to store the surplus waters of storms, and have them ready for the seasons of drought. This source of abundant and convenient water supply should be secured for the use of all the people inhabiting the district between the Watchung mountains and the Hudson river. And it should be secured soon, so that it may not be appropriated to the use of a part of the people, or be taken away for the benefit of more enterprising people on the east of the Hudson.

With proper care and time an adequate supply of water can be got from the Upper Passaic by storing the surplus in reservoirs, without diminishing the amount required daily for the water power at Paterson and Dundee.

IX.

STATISTICS.

IRON ORE.

The product of our mines of iron ore for the year (1881) as shown by the shipments of the several railroad companies, and the statistics of the furnaces, which receive some of these ores directly from the mines by teams, amounted to 737,052 tons. The statistics for the past decade, and the estimated output at intervals back to 1790, are put in a tabular statement below:

1790	10,000 tons	Morse's estimate.
1830	20,000 tons	Gordon's Gazeteer.
1855	100,000 tons	Dr. Kitchell's estimate.
1860	164,900 tons	U. S. census.
1864	226,000 tons	Annual Report State Geologist.
1867	275,067 tons	Annual Report State Geologist.
1870	362,636 tons	U. S. census.
1871	450,000 tons	Annual Report State Geologist.
1872	600,000 tons	Annual Report State Geologist.
1873	665,000 tons	Annual Report State Geologist.
1874	525,000 tons	Annual Report State Geologist.
1875	390,000 tons	Annual Report State Geologist.
1876		
1877		
1878	409,674 tons	Annual Report State Geologist.
1879	488,028 tons	Annual Report State Geologist.
1880	745,000 tons *	Annual Report State Geologist.
1881	737,052 tons	Annual Report State Geologist.

The U. S. Census Bulletins, recently issued, enable us to give the following items relative to the production, the working force, capital, &c., employed:

* The product for 1880, as published in the Annual Report for 1880, was in error. It should have been 745,000 tons.

Number of establishments	109
Maximum yearly capacity	1,487,829 tons.
Product for census year	757,372 tons.
Value of product	$2,910,442
Value of materials used in regular industry	584,229
Wages paid	1,606,257
Total	$2,190,486
Number of men employed	4,649
Total number of employes	4,811
Value of machinery	$519,954
Working capital	562,915
Value of plant	841,226
Value of real estate	4,797,620
Total capital	$6,201,761

In the list of iron-producing States, New Jersey ranks fourth, being exceeded by Pennsylvania, Michigan and New York. And the same relative rank is maintained as was shown by the census of 1870. Her proportion of the total product of the country is 9½ per cent., about one-tenth of the whole.

Of the total product of the State, Morris county produced 568,420 tons, or 75 per cent. Its rank among the counties of the United States is third. Marquette county, Michigan, and Essex county, New York, alone surpass it in amount. Sussex county ranks sixteenth, and Warren county twenty-sixth, in this list of counties. Among the large mines the Hibernia ranks eighth, having produced 138,173 tons.

The census statistics give the average cost per ton of ore, as distributed in labor, materials, interest and royalty. While the cost of labor is larger in New Jersey than in the other large iron-producing States, the price of the ore at the mines is here greater than elsewhere, excepting in Missouri. In the per cent. ratio of value of yearly product to total capital, New Jersey ranks high, being 46.77, while in the other large iron-producing States it varies from 24.51 to 42.34. These figures indicate the business as a steady and profitable one.

In relative rank of production of iron and steel, New Jersey ranks fifth, having dropped from the fourth place in 1870, although its increase has been 112 per cent. Its rate of increase was surpassed by Illinois only, among the large iron-manufacturing States.

ZINC ORE.

The New Jersey Zinc and Iron Company, and C. W. Trotter work the zinc mines on Mine Hill, at Franklin; at Ogdensburg, the Sterling Hill mines are worked by the Manganese Iron Company, the Passaic Zinc Company, and the New Jersey Zinc and Iron Company. The latter company has taken out a large amount of ore at each of these places, and its activity appears in the greatly increased product of our mines. The railroad companies report shipments of 49,178 tons of zinc ore from these mines. The increase is shown in the following tabular statement of production for several years past:

Estimate 1868	25,000 tons.	1878	14,467 tons.
Estimate 1871	22,000 tons.	1879	21,937 tons.
Estimate 1873	17,500 tons.	1880	28,311 tons.
Estimate 1874	13,500 tons.	1881	49,178 tons.

CLAYS AND BRICK.

The statistics of clays, *kaolin*, fire sand and other materials of a refractory nature, which are dug in Middlesex county, may be grouped as follows:

Woodbridge, Perth Amboy and north bank of Raritan, fire brick, fire clay and other refractory materials (estimate for 1880)	197,800 tons.
Clay banks on the south side of the Raritan river: "Fire clay," "ware clay," "foundry clay" and "retort clay"	50,000 tons.
Stone ware clay.*	15,000 tons.
Clay for yellow ware, pipe, &c.*	5,000 tons.

Henry Maurer, manufacturer of fire brick, hollow brick for fire-proof buildings, reports using 5,000 tons of fire clay during the year, in the manufacture of 520,000 hollow brick, and 1,750,000 fire brick, gas retorts, tiles, &c., &c., at his works, near Perth Amboy.

From the clay banks along the Delaware river, the shipments of clays and refractory materials amount to 42,200 tons.† This estimate includes, however, 10,750 tons of *foundry gravel* from the

* From Otto Ernst, of South Amboy.

† From John D. Hylton, of Palmyra.

Pensauken creek banks, of John D. Hylton. About two-thirds of the total clay product of this side of the State comes from the same bank.

The statistics of red brick for 1881, as estimated by the large manufacturers in the several brick-making centers, are—

Raritan and South river yards	60,000,000	red bricks.
Raritan bay and Matawan yards	19,000,000	"
Delaware river yards, Trenton and Kinkora (including 6,000,000 of pressed or front brick)	19,500,000	"
Delaware river, Fish House	8,000,000	"
Total	106,500,000	

To this total there should be added several millions for the yards in the northern part of the State, and elsewhere, to supply local demands. A high estimate of their production would be about 10,000,000.

STATISTICS OF POTTERIES MAKING WHITE WARE AT TRENTON, ELIZABETH AND JERSEY CITY.*

Number of kilns	110
Average capacity (each)	$30,000
Amount produced, if fully employed	$3,030,000
Amount actually produced, about	3,000,000
Amount produced in United States	5,000,000
Amount imported, about	4,000,000
Production of New Jersey (clays, flint and spar)	50,000 tons.
Coal used	50,000 tons.
Wages paid, yearly	$1,400,000
Hands employed	3,000

The figures of this table are reprinted from the Annual Report for 1880, as there is no material change in the statistics. Rapid strides are making in the work of decorating wares. And there is an increased production of higher class wares.

GLASS SAND—GLASS STATISTICS.

Sand for glass making is dug extensively at several localities in the State for use in glass works, and for the supply of establishments in the adjacent States. The principal localities and its modes of occurrence were described in the Annual Report for 1878, pages 70–80.

* From Hon. J. H. Brewer, Etruria Pottery Co., Trenton, and President of the United States Potters' Association.

The United States Census Office collected the statistics of these pits for the year ending June, 1880, and, through the courtesy of the Superintendent of the Census, we are permitted to present the following facts relative to their operations for that (census) year. Capital $43,500; men employed, 46; product, 27,495 tons, valued at $31,000. The aggregate value of the crude article is not large, but its place in our State is the basis of the glass manufacture of South Jersey. And the importance of this industry is apparent from Bulletin No. 118 of the census office, giving the statistics of glass manufacture in the United States. According to this bulletin, there are in the State, for the manufacture of window glass—

15 furnaces, having 111 pots.
622 employes.
Product, $729,155.

For making glassware—

10 furnaces, with 89 pots.
900 employes.
Product $400,000.

For making green glass, there were—

30 furnaces, with 164 pots.
1,979 employes.
Value of product, $1,681,015.

In all, 55 furnaces; 364 pots; value of product, $2,810,000.

In the manufacture of green glass, the State leads all the others, one-third of the total product of the country being made in New Jersey.

GREEN-SAND MARL.

The statistics of marl sales and shipments during 1881, received from the several companies, indicate no great material change in the amount of business done. The reports show a slight increase in the output, and the total amount shipped by eight companies aggregates 73,900 tons. The Squankum Marl Company is about to be re-organized, and did no business. The increase in the total production of the eight companies from which we had reports of shipments for 1880 and 1881, amounts to 15 per cent. The general prosperity of the country and the good prices received for farm produce warrant the belief that the marl trade will continue to increase and grow to larger proportions as a steady business. The value of this great natural fertilizer is more and more appreciated as it is used. And the companies are doing our agriculture a great service in extending its use as such, without resorting to any doubtful expedients of fanciful names, or *improved* mixtures, at high prices.

The reports from the several companies are here presented:

Freehold and New York Railway.

J. E. Ralph, Secretary and Superintendent of the road, writes: The Freehold and New York Railway hauled, during the year, only 242 car loads, of 250 bushels each, equal to 60,500 bushels.......... 3,025 tons.

Squankum Marl Company.

W. E. Barrett, Superintendent, says: Owing to business changes in progress, no work has been done this season.

Freehold and Squankum Marl Company.

G. D. Gilson, Superintendent, says: The amount of marl sold and delivered in 1881, is.......... 17,732 tons.

Cream Ridge Marl Company.

Gen. G. Mott, Treasurer, writes: The company has sold and sent out by cars during the year 1881.......... 6,879 tons.

Pemberton Marl Company.

J. C. Gaskill, Superintendent, writes: Our sales of marl for the last year have amounted to.......... 9,000 tons.

Vincentown Marl Company.

Henry J. Irick, Secretary, writes: Our marl company was only operated the last five months of 1881, and shipped.......... 3,000 tons.

Fostertown Marl Company.

R. S. Reeve, Lessee, reports: We shipped, a decided increase over the past three years, about.......... 8,000 tons.

Kirkwood Marl and Fertilizer Company.

Geo. M. Rogers, Superintendent, writes: Our sales have increased over 2,000 tons, being, for the year ending.......... 9,887 tons.

West Jersey Marl and Transportation Company.

A. J. Delp, Superintendent, writes: Our company sold and delivered in the year 1881.......... 13,377 tons.

Dickinson Marl Company.

John W. Dickinson reports sales as amounting to.................. 3,000 tons.

Marlborough, Monmouth County.

J. E. Ralph contributes the following statement from Mr. O. C. Herbert: Sales during 1881,* 6,480 tons; and estimates for pits of the late Uriah Smock, A. W. Hobart and John Van Kirk, 10,000 tons; total.. 16,480 tons.

* Exclusive of shipments by F. & N. Y. R. R., which are included above under that head.

F

X.

PUBLICATIONS OF THE SURVEY.

The ANNUAL REPORTS OF THE STATE GEOLOGIST are printed as part of the legislative documents of the State. And they are largely distributed by the members of the Legislature. Extra copies printed are distributed by the members of the Board of Managers, and the State Geologist also distributes copies to libraries, institutions of learning, and to persons interested in such work. A list is kept of those to whom distribution is made regularly, but the demand for the last report far exceeded the supply. Several of the reports of preceding years are all distributed, and of others but few copies are left.

There are still a few copies left of the GEOLOGY OF NEW JERSEY, the octavo volume and maps printed in 1868.

The REPORT ON THE FIRE AND POTTERS' CLAYS OF NEW JERSEY, with a map of the clay district of Middlesex county, published in 1878, has been very widely distributed. There are copies still on hand for distribution.

The copies of the LARGE GEOLOGICAL MAP of the State are nearly all distributed.

A PRELIMINARY CATALOGUE OF THE FLORA OF NEW JERSEY, prepared by N. L. Britton, Ph. D., has been printed during the year, and distributed to botanists for their remarks, corrections and additions. A great many of the plants have been noticed in only a single place in the State. By the circulation of this catalogue among botanists, it is hoped that many new localities of rare plants will be discovered, and the list thoroughly revised. The catalogues are to be returned after one or two seasons, and the notes in them used in making out a more perfect catalogue, for general circulation throughout the State. Only 600 copies were printed, and these have already been placed in the hands of working botanists, and much work has been accomplished in its revision. The work commends itself to all lovers of botanical science, and we are promised their hearty co-operation in completing the revised edition.

A Topographical Map of a Part of Northern New Jersey, on a scale of one mile to an inch, is just ready to be issued now. In addition to the delineation of boundaries, streams, roads and geographical matter, it has on it contour lines of level, so that the elevations of the surface above mean tide are accurately marked on all parts of it.

Geological Map of New Jersey.—Scale six miles to an inch. The improvements going forward in the State, call for a revision of our map very often. There have been 151 miles of new railroad built in New Jersey in 1881. There were 1,725 miles at the beginning of the year, and now we have 1,876 miles for our 7,576 square miles of area, which is about one mile of railroad for every four square miles of area in the State. These are laid down on the map, and the agricultural, mining and other great interests, dependent upon the geological structure of the State, and on the location of its various formations, render it of the highest importance to keep the subject prominently before our people.

The results of the Survey are intended for the benefit of the citizens of the State, and the Board of Managers have charge of and direct the distribution of its collections, reports and maps. The addresses of the members of the Board are given on page 3 of this report, and application made for publications to them, or through them to the State Geologist, will be received and given due attention.

XI.

EXPENSES.

The expenses of the work have been kept within the annual appropriation. The absolute necessity for accurate geographical and topographical maps for delineating, defining and studying geological phenomena, has led to the curtailment of expenses in some directions and to their increase in others. The expenses of the laboratory have been temporarily suspended, those in geological field-work have been greatly diminished, and those for making surveys have been largely increased. And the expenses of work for the coming year must be distributed among the different branches in nearly the same way that it has been during the year just passed.

XII.

PERSONS ENGAGED IN THE WORK OF THE GEOLOGICAL SURVEY.

Prof. JOHN C. SMOCK, Assistant Geologist, is still attached to the Survey, and has devoted much time to the preparation of the Appendix, which gives a fuller account of the climate of New Jersey than has been written before this. An engagement for a part of his time in collecting statistics of quarries and building stones, in the States of New Jersey and New York, has given him the opportunity to prepare important material upon that subject for this report.

EDWIN H. BOGARDUS, Chemist for the Survey for several years past, closed his connection with it in April last, and the chemical laboratory has not been in operation since.

C. C. VERMEULE, C. E., Topographer and Surveyer, has been steadily at work during the entire year; field work keeping him occupied during the season of open weather, and draughting in the office being done in the winter. He has been assisted in the field by PETER D. STAATS, who has conducted odometer surveys; by JOHN T. MARSHALL, FREDERICK W. BENNETT, PHILIP H. BEVIER, SOL'N LE FEVRE, N. D. VAN SYCKEL, CYRUS W. F. SPROUL and WM. MCKELVEY, who have been engaged in the running of levels, and general topographical work.

N. L. BRITTON, Ph. D., has completed the Preliminary Catalogue of the Flora of New Jersey, and has occupied some time in getting specimens and improving our collection of fossil plants, which are to be used for description and figuring.

Prof. J. S. NEWBERRY still has in hand the work of figuring and describing the fossil fishes and plants found in New Jersey. The work is mostly done, and only awaits some prospective addition of new specimens.

Prof. R. P. WHITFIELD is engaged upon the descriptions of the fossil invertebrates of the Cretaceous formation, and is making progress with them. The securing of characteristic specimens of the numerous species that have been found, delays and so prolongs the work.

My own time has necessarily been mainly occupied in keeping the different branches of work in effective progress, in securing the greatest possible benefits from the United States geodetic surveys which are now going on in our State. The field work which I have done, has been chiefly in detached parts, which were needful to complete gaps in work mostly done.

XIII.

WORK TO BE DONE.

PLAN FOR THE COMING YEAR.

The continuation of topographical surveys over the remainder of the Archaic rocks of the State will be prosecuted during the coming season, as rapidly as the means at our disposal will allow; and it is expected that the field work of surveying this formation, which contains all our mines of magnetic iron ore, will be completed this year.

The practical questions in regard to soils, fertilizers, building materials, rocks, ores, &c., which are continually being asked, must necessarily occupy attention, as far as provision can be made for examination, and they will receive it.

The Board of Managers considering that the subject of water supply is becoming more and more important in our State every year, have directed that it be made the special work of the Survey the coming year.

The collection of fossils, and preparing the drawings and descriptions of them is going on, and it is hoped that some part of this work may be completed and ready for publication in the course of the year. In collecting fossils we are largely dependent on friends and amateur collectors for the use of choice specimens for description.

The collection of the plants of the State is going forward, and we are glad to report that several hundred amateurs are helping to fill out and perfect it.

APPENDIX.

CLIMATE OF NEW JERSEY.

BY PROF. J. C. SMOCK.

INTRODUCTION.

Climate has been defined to be "that peculiar state of the atmosphere, in regard to heat and moisture, which prevails in any given place, together with its meteorological conditions generally, in so far as they exert an influence on vegetable and animal life." Practically, all of its phases may be traced, either directly or indirectly, to the sun. It is the great source of all terrestrial heat so far as life on our globe is concerned. In consequence of the earth's spheroidal shape, and the inclination of the plane of its equator to that of the ecliptic, the sun's rays do not everywhere fall vertically upon its surface, but at different angles at different places, and at different seasons of the year in the same place. Accordingly as they are more nearly vertical they traverse a less thickness of the atmosphere and a greater number of them fall upon a given area. Hence, other things being equal, the more heat such a surface will receive. From this varying inclination of the sun's rays comes our word climate, through the Greek verb which means *to incline.* In the equatorial zone or belt, the sun's rays strike the surface vertically, but as we go thence towards either pole, they are more inclined, and, consequently, the distance from the equator, or latitude, is the most important element in the consideration of the climate of any country. And, if there were no others, we should have what have been called solar climates, that is, parallel zones of the earth's surface decreasing in temperature from the equator to the poles. Any map with isothermal lines, shows at a glance, however, that the lines of equal heat do not follow the parallels of latitude, but differ widely from them. Thus, the western coast of Norway enjoys a milder climate than that of our Middle Atlantic States, although there is a difference of 20 degrees of latitude between them. The western, or Pacific coast of our own country has its mild winters and cool summers as compared with our greater extremes on the Atlantic coast. The winter temperature of Reykjavik, in Iceland, in latitude 64°, is 29°, or above that of our Highlands. The northern limit of the beech in Norway is about 60° N. latitude, whereas in British America it does not extend beyond the 50th parallel. Examples could be multiplied indefinitely, showing like variations. Climatology seeks the causes of these differences and peculiarities. The principal disturbing, or modifying factors of climate may be reduced to these four, viz.: I. Relative position of land and water; II. Prevailing winds; III. Height above the ocean, or elevation; IV. Configuration and nature of the surface and of the surface covering.

I.—RELATIVE POSITION OF LAND AND WATER.

The well known capacity of water for heat is so much greater than that of the solid matter of the earth's surface, that the sun's rays do not heat it so quickly as they do the land, nor does it give off its heat so rapidly and cool as quickly. In consequence of this property of water the effect upon climate is such that places are said to have a marine, or continental climate, according as they are situated near the sea, or in the interior of continents. Water not only absorbs heat, but distributes it also. Ocean currents are mighty agents in this distribution. Thus, the heat carried into the North Atlantic by the Gulf Stream affects the climate of all western Europe, and is felt as far as Nova Zembla and Iceland. The heat of the tropics is, as it were, carried to the arctic regions. But there are cold currents also which have an effect on the shores along their courses. Our own coast is washed by the arctic current, which flows out of Baffin's bay and from the eastern shore of Greenland, southward and southwest, passing Labrador, Newfoundland, Nova Scotia, and thence along the New England and our Atlantic coast. The influence of both of these oceanic currents is felt on our shore, although it is much less than on islands which lie in their courses. In the Pacific and South Atlantic oceans like currents exert a great influence upon the climates of the globe. Another effect of large bodies of water upon temperature results from a *vertical circulation.* On account of the greater density of cold water, the surface layers, which are chilled by cold land winds, sink and are replaced by warmer masses. In this way a vast amount of *cold* is buried in the depths of the sea. The general effect of situation near the ocean or upon islands is the reduction of extreme temperatures and a more equable climate. The cold of winter is less severe and the summer's heat is not so intense as in the interior of a continent. For illustration, in the Bermuda Islands, in the same latitude as Charleston, S. C., frosts are unknown, and the highest and lowest recorded temperatures are, respectively, 86° and 49°. The mean annual temperature is about 70°. At Charleston the observed extremes are 101° and 13°; and the mean for the year is 66°. Following the parallel of 32° 20′ west, to Texas, the extremes are still wider apart. The Pacific coast climates show the influence of the sea to a very marked degree. In the San Joaquin valley the summer mean is 84°, while on the coast, west of the Coast Range, the mean is but 60°, a difference of 24° on the two sides of this chain. The isothermal lines here run parallel to the coast for 600 miles and across the parallels of latitude and what would be the normal isothermals. The southern coast of England is noted for its mild winters, and tender plants bloom out of doors the whole year, while at London and in the interior there are frosts and snows. On the western coast of Scotland and in the Hebrides, thick ice is almost unknown, and snow seldom lies for any length of time; in the Scottish Highlands the winters are noted for their snow. These are examples of oceanic and of insular climates. Of continental climates we know through the extremely low temperatures which are reported from our northwestern states and territories, where the thermometer falls to 40 or more degrees below zero. It would seem as if in these interiors there was an interchange of the torrid and arctic zones and that our north temperate zone partakes somewhat of the extremes of both of them. Or, in other words, we have a sub-tropical summer and an arctic winter. Although the general influence of the ocean waters is to produce an equable climate, that at any given locality is somewhat determined by the nature of the currents off the shore and the direction of the prevailing winds. The latter may help in carrying inland the warmth of the equatorial waters, or, if they come from land surfaces, they may counteract and neutralize the moderating influences of warm currents. But, in general, the distance a place is from the shore becomes a partial measure of this equalizing effect of the sea upon its climate. This effect is not confined to temperature alone. The amount of moisture, the composition and character of the air, and its pressure or weight, are all more or less modified by nearness to the water. The greater humidity of oceanic and insular situations tends to interfere with radiation of heat from the surface and thereby prevent the alternations of heat and cold which are so marked in very dry regions where radiation is rapid. There are other sensible differences which are felt at the sea side and which affect us, but which we cannot exactly define or measure.

II.—PREVAILING WINDS.

The atmosphere, like the ocean, is traversed by currents, and cold air, like cold water, is denser than warm, and consequently there is a constant circulation—air currents which sweep over vast areas of the globe, carrying with them heat from the equatorial to temperate zones, and the warmth gathered from ocean currents, far inland. The trade winds, the sirocco, and others known by local names, are such carriers and distributers of heat. Wherever the prevailing winds come from water areas, they bring with them the equalizing effects of water, and the equable climate of ocean or insular locations are thus felt further inland than in those islands or coast localities which are on the sides of continents opposite to the direction of the prevailing wind-quarter. Thus the prevailing southwest winds in Great Britain give them a moist and mild climate, whilst on our Atlantic slope the prevailing winds are land winds, excepting as they are moderated in their intensity by the small bodies of water partially connected with the Atlantic and along our coast. The popular "cold waves" are the transferrence of great bodies of cold air from west to east across our continent through the agency of the prevailing land currents. These westerly winds, in the summer, bring us the heated air of the southwest. Thus they serve to intensify our extremes of temperature by excessive heat in summer and severe cold in winter. Inasmuch as they prevail over the easterly and southeasterly (which are our sea winds), the climate has a continental character. It is only as the sea winds and sea breezes reach further inland, and blow more frequently, that our climate can partake of an oceanic or insular character. The measured effects of these air currents, as recorded by the thermometer, are often sudden and very considerable. Changes of temperature of 63 degrees in 41 hours have been recorded in northern Texas. In Paterson, in our own State, recently, there was a change of 48 degrees in 17 hours—due to a "cold wave" from the West. The delightful cooling temperatures which accompany our sea breezes are so well known that it is not necessary to give further examples of winds.

III.—HEIGHT ABOVE OCEAN LEVEL OR ELEVATION.

The decreasing temperature experienced in the ascent of high mountains, the gradual change in the forest and the disappearance of all timber, and then the region of eternal snow and ice, give evidence of the influence of elevation alone in attempering even the heat of the torrid zone. The lofty Andes are thus snow-covered throughout nearly their whole length, although they extend across the whole breadth of the equatorial belt. But in our eastern Atlantic States the lingering snows found in the early summer on the Alleghanies, Catskills, and on the White Mountains, show the diminution in the heat as compared with the lowlands about their bases. The rate of decrease due to elevation is, in general, about one degree for every 300 feet of rise. It is somewhat modified by the configuration or shape of the surface. Southern slopes are warmer than northern, and the nature of the surface also has much to do with this decrease. Narrow ridges bounded by broad plains or valleys do not show so great differences as are observed on table lands. Observations made in balloon ascents indicate a more rapid decrease. Glaisher, a celebrated English meteorologist, found a difference of one degree for each 162 feet rise, when the sky was clear. But in the case of mountain chains or table lands the rate of one degree per 300 vertical feet is a safe one for estimation of upland temperatures. The general effect of elevation is therefore to reduce temperatures. That mountain crests and tops are more exposed to winds is almost self-evident. The U. S. Signal Service records of observations on Mt. Washington give many remarkable examples of low temperatures in the warm months of the year, and excessively high winds—equivalent to gales of lowlands. The freer circulation of the air on elevated points makes the heat more endurable.

But the temperature of elevated localities is sometimes increased relatively, as compared with that of deep valleys near them. And this phenomenon occurs frequently in still cold weather. In such times, when the atmosphere is not disturbed by winds, the cold air of the higher ground or mountain crests, like the denser cold water, flows down into the adjacent valleys, displacing the warmer air, which in turn ascends, being lighter, to the more elevated localities. This transferrence of cold air to lowlands is often noted in crossing narrow, deep valleys at nightfall in the summer season. And in early autumn the colder air of the valleys is proved by the presence of frosts when there is none on the adjacent higher grounds. In cases of extremely cold weather differences of 10° to 15° have been observed at points less than a mile apart. This phenomenon is so common in the Alps, that distinctive names have been given to the cold currents which flow down the valleys from the higher peaks. In our Highlands, differences of at least 12° have been observed between the summit of Schooley's Mountains and Hackettstown. The deep, narrow valley of the Delaware, between Lambertville and Milford, is said to exhibit a like phenomenon.*

Elevated table lands and mountain chains also serve to break the force of the wind in narrow valleys lying at their feet, and thus, to some extent, shield the latter. They also serve as condensers of the moisture of the atmosphere, and clouds drifting about mountain summits and the accompanying rainfall, when the neighboring lowlands are passed over dry, is another phenomenon common in mountainous countries. Especially is this the case where the mountains are so situated as to catch the prevailing winds, and still more so if the latter come from the ocean, or are sea winds. The extraordinary heavy rainfalls of Cumberland, in England, and of the Southern Himalayas, are striking examples of this effect of mountains. The general effect of elevation is somewhat like that of the ocean, although only within certain limits, and in a far less degree, do they moderate the extremes of cold.

IV.—THE INFLUENCE OF THE SURFACE—BY ITS CHARACTER AND COVERING.

The excellence of some solid bodies like sand and some rock to arrest heat, is well known. They are easily warmed, and almost as

*Recent observations made upon the summit of Puy-de-Dome and at Clermont, in France, during the winter of 1879-80, show that frequently the temperature was higher upon the mountain than at Clermont. The elevation of Puy-de-Dome is 3,540 feet above Clermont. The mean temperature for December on the mountain was 18° higher than it was at Clermont.

readily part with their heat. This peculiarity of the solid masses of the earth's surface, as distinguished from water, explains the intense heat of such surfaces when exposed to the vertical rays of the sun. And the rapid radiation of the heat during the night produces extreme cold. Hence the alternations of temperature by day and by night are much greater in the surface layers of the land than in that of the water. It is the primary cause of the difference between the land and the water. But there is a great variation in the nature of the surface, and its effect upon climate, or upon the superincumbent air stratum, is as diverse as its nature. In the deserts of Asia and Africa temperatures far above 100° have been observed in thermometers placed in the sand. And everywhere bare ground becomes more heated than the grass-covered field. The difference is almost self-evident. Hence wide-spread sandy plains are more heated than rich, fertile lands which are covered by luxuriant crops. This more intensely heated surface heats the layer of air in contact with it, and induces a circulation so as to allow a cooler stratum to take its turn in being heated. Of course, in our temperate climates, the effect is not so marked as in the Sahara or in other torrid wastes. But its influence is capable of measurement, and is plainly evident to the traveler crossing such tracts. The general result is, therefore, a production of extremes. In the day time the maximum is heightened and at night the minimum is depressed, and the daily range of temperature is increased. Such wastes also allow of the freer, more unobstructed passage of winds, which thus serve to intensify the changes. They render the climate more excessive, and neutralize, to some extent, the influence of proximity to the sea.

The surface covering of grasses and grains serves to protect it from the fierce rays of the sun, and also to shield it from the cold of winter.* This moderating influence of these lowly growths is greatly increased in the case of the natural land vegetation—or forest. Trees intercept by their thick foliage the sun's rays, and by their shade protect the soil. Their leaf mould and the natural undergrowth still further protect the earth, so that often the ground remains unfrozen in the woods, when in adjacent fields or open spaces the frost penetrates deeply. The covering of trees acts therefore as screen against sun and wind, and serves to maintain a more even temperature in the

* On the other hand, grass-covered soils are cooler in summer and warmer in winter than bare ground. Observations by Edmond and Henry Becquerel show a difference; and prove that the difference may amount to 5.7° at a depth of 2 inches.—*Nature, Dec.* 1st, 1879.

soil.* But the temperature of the air also is more even in woods than outside. Observations at Aschaffenburg, in Bavaria, give a mean result of 1.3° difference in temperature for the year. These figures are incontestible evidence of the effect of forest in lowering the summer temperature and raising that of winter. It is analogous to that of the sea.

The forest also serves as a wind-break or screen, and violent winds are not so common in wooded regions, as there is not the unequal heating of the surface which elsewhere tends to produce currents, or disturb the low-lying strata of the atmosphere. The general influence of forests is to make the temperature more even—to retain the moisture of the soil longer, to arrest and condense rain-giving clouds, and hold the rains and snow longer in and on the surface, and to produce a more equable and moist climate.

NEW JERSEY—CLIMATIC DIVISIONS.

TEMPERATURE.

The situation of New Jersey on the Atlantic slope of the continent, between the ocean and the higher ranges of the Appalachian chain, gives it a continental climate, very greatly modified by its proximity to the ocean, and by its varying configuration of surface. The constant play of these disturbing elements in the climate produce variety within comparatively narrow limits. And the State, although small, exhibits diversities, which correspond somewhat with its varied surface features. The elevation of the northern part and the nearness of the southern portion to the sea tend to heighten the influence due to difference of latitude only. The nature of the soil and the forests of the southern interior also counteract the effect due to proximity to the ocean, and still further modify the climate in that part of the State. To properly estimate the influence of these factors is the difficult problem of the student of climatology. Records are still too few in number and too short to define the result of their operation at every locality. But we can approximate closely to it in the several well marked and natural divisions

* "According to the third annual report of the Forest Meteorological Stations of Germany, being the report for 1877, we learn that this system of inquiry into the influence of forests on weather and climate now includes fourteen stations. * * * * The results show in every case a lower air temperature inside the wood as compared with the open country outside, the mean difference being 1.3°. As regards the temperature of the surface of the ground, the mean deficiency in the wood shaded by the trees is 2.5°, an amount which gradually diminishes with the depth to 2° at 48 inches, the lowest depth observed."—*Nature, March 6th*, 1879.

of the State. And we may accept these divisions as the natural climatic provinces. Their subdivision must come after further observations have been made, so as to fill the wide gaps now existing between stations. This provisional division has for its basis the geological structure, and the study of our climate is, therefore, an outgrowth of that of our physical geography and of our geology. The six divisions or climatic provinces of the State are, beginning at the north, as follows:

I. The Kittatinny Valley and the Highlands.
II. The Red Sandstone Plain.
III. The Southern Interior.
IV. The Atlantic Coast Belt.
V. The Delaware Bay Belt.
VI. The Peninsula of Cape May.

A further subdivision of the first and second of these provinces is indicated by their structure. The first contains really three well marked, natural divisions—the valley of the Delaware river, the Kittatinny Valley and the Highlands. The trap-rock ranges mark out three divisions of the Red Sandstone Plain. But there are no records to enable us to show that they exist in fact. They are indicated by the structure of the country. In the southern part of the State there are so many stations and so distributed that their records determine the divisions here made as natural provinces, each having its peculiarities of climate. It will be understood at the outset that while these divisions have definite characteristics, it is not possible to define sharply their boundary lines, or to indicate where the one ceases and the other begins, since they shade by insensible graduations into one another. This gradual change is especially true of the southern divisions. In the northern part of the State the more abrupt changes in elevation, and in the nature of the surface, and of geological formations, produce marked differences in climate.

The geological map of the State, accompanying this report, will serve to illustrate the location and the limits of these climatic divisions, and the localities mentioned in the description of them.

Their boundaries, extent, elevation and general surface features, which modify the general character of our climate, together with local peculiarities induced by their varying intensity, are described under their respective heads.

Introductory to these descriptions of the several provinces, and in order to convenience of reference, we give at the outset a table of mean temperatures for each month, season, and the year, in each of these six divisions of the State. The mean temperatures are obtained by taking the averages of the stations which are selected as representative of them. Thus that of the first is the average of the mean daily temperature by months, as recorded at Goshen, and Port Jervis, in Orange county, N. Y., Easton, Pa., and Dodge Mine, Morris county. The same method is used to get that for the seasons and the year. The figures of the table give the degrees and hundredths, according to the Fahrenheit scale.

TABLE I.

Mean Temperature for each Month, Season and the Year, for the several Divisions of the State, *Expressed in Degrees and fractions of a Degree, according to Fahrenheit's Scale.*

	MONTHS.											
	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
I.—Kittatinny Valley and the Highlands, from records at Goshen and Port Jervis, N. Y., Easton, Pa., and Dodge Mine	24.68	26.46	34.33	46.27	56.89	64.75	69.97	68.13	60.89	48.94	38.19	28.80
II.—Red Sandstone Plain, from records at Newark, New Brunswick, New Germantown, Lambertville, Princeton and Trenton	28.72	30.02	37.25	48.70	59.25	68.85	73.85	71.36	63.84	52.57	41.48	31.86
III.—Southern Interior, from records at Freehold, Burlington, Mount Holly, Moorestown, Haddonfield, Philadelphia, Pa., Atco, and Vineland	30.46	32.25	38.92	49.79	60.77	70.71	75.61	72.58	65.27	53.83	42.76	33.07
IV.—Atlantic Coast Belt, from records at Sandy Hook, Barnegat and Atlantic City	31.90	32.52	38.17	46.12	55.48	64.93	70.53	70.91	66.50	54.97	44.83	35.40
V.—Delaware Bay Belt, from records at Greenwich	32.69	34.14	40.90	50.63	61.37	70.87	76.20	73.44	66.01	54.93	44.15	35.25
VI.—Peninsula of Cape May, from records at Cape May	34.61	35.35	41.03	48.59	56.68	66.45	72.07	71.56	66.97	57.42	47.42	37.99

TABLE I.—*Continued.*

	Year.	Seasons. Spring.	Summer.	Autumn.	Winter.	March of Seasons. Winter to Spring.	Spring to Summer.	Summer to Autumn.	Autumn to Winter.
I.—Kittatinny Valley and the Highlands, from records at Goshen and Port Jervis, N. Y., Easton, Pa., and Dodge Mine	47.32	45.83	67.62	49.17	26.65	19.18	21.79	18.45	22.52
II.—Red Sandstone Plain, from records at Newark, New Brunswick, New Germantown, Lambertville, Princeton and Trenton	50.60	48.40	71.35	52.63	30.03	18.37	22.95	18.72	22.60
III.—Southern Interior, from records at Freehold, Burlington, Mt. Holly, Moorestown, Haddonfield, Philadelphia, Pa., Atco, and Vineland	52.17	49.83	72.96	53.95	31.93	17.90	23.13	19.01	22.02
IV.—Atlantic Coast Belt, from records at Sandy Hook, Barnegat and Atlantic City	51.02	46.59	68.80	55.43	33.27	13.32	22.21	13.37	22.16
V.—Delaware Bay Belt, from records at Greenwich	53.38	50.97	73.50	55.03	34.03	16.94	22.53	18.47	21.00
VI.—Peninsula of Cape May, from records at Cape May	53.02	48.77	70.02	57.27	35.98	12.79	21.25	12.75	21.29

This table exhibits the gradual increase in the mean temperature of the months, of the seasons, and of the year, as we go from north towards the south, or from the Atlantic coast west-southwest. This difference between the Kittatinny valley and the Delaware bay belt amounts to one month in the early spring, *i. e.*, the temperature of February in the latter is as high as that of March in the former. The differences of the seasons in the several provinces are not so great as in individual months. In general, it may be said that there is a difference of one month in the spring, and very nearly a month in the late autumn or at the beginning of the winter. The mean annual temperature ranges from 47.32° in the north to 53.38° at the southwest, a difference of about 6°, corresponding to 3° of latitude, or slightly more than the difference between the extreme north and south ends of the State.* New Jersey stands at the eastern end and near the south limit of the populous belt of our country, lying between the annual means of 45° and 55° of heat, and comprising the New England States, the Middle Atlantic States and the northern half of the great Mississippi valley.

A graphical representation of the table is given in plate I. The

*The latitude of Carpenter's Point is 41° 21′ 22.63″. That of Cape May light-house is 38° 55′ 50″, a difference of 2° 25′ 32″, equivalent to 167.4 miles.

figures at the side express the mean temperature in degrees. These are connected by horizontal lines. The months are represented by vertical lines. The several divisions are represented by curved lines, and where these latter cross the monthly lines we have the temperature for months. The curves show the rapid increase of heat in the spring, particularly in April and May, in all parts of the State. The more gradual rise to the July maximum, and the varying rate of decline to August, are plainly shown. September and October bring the curves nearer together, as the heat decreases. In November we note the greater variation between the several divisions. The greatest difference appears in the winter months.

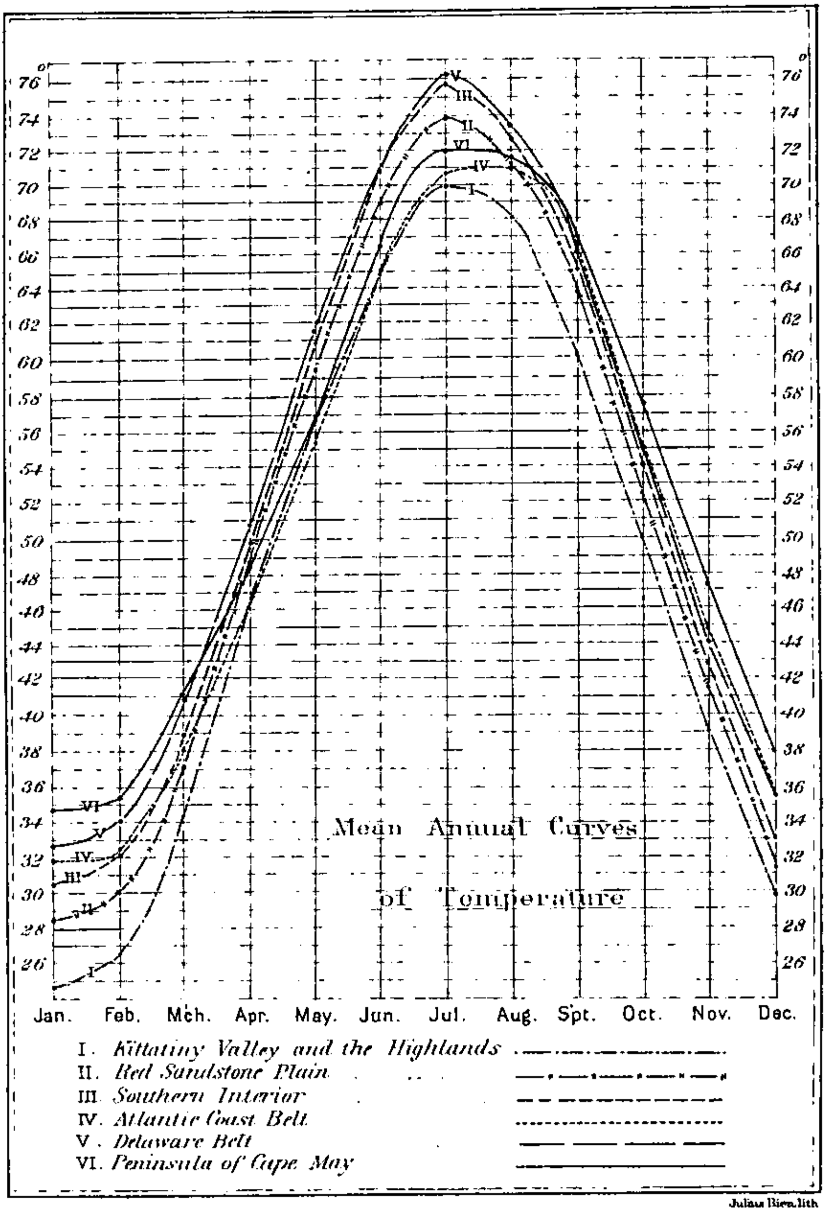
The difference in mean temperature in the spring months has a marked effect upon vegetation, and the flowering of fruit trees is about three weeks earlier in the extreme southern part of the State than on the Highlands. The small fruits also come earlier and are marketed before the picking begins in the central and northern counties. Early vegetables are produced in the southern part of the State as early as in Virginia. Melons, sweet potatoes and other semi-tropical products which thrive so well in the central and southern counties are scarcely attempted in the extreme north. There appears to be a difference of a week or so between Lambertville and the immediate Delaware River valley, and places in the interior and eastern side of the State, on the same parallels of latitude, in the earlier blossoming of certain plants and fruit trees.* But further observations are needed to indicate the extent of these differences of locality within our borders. The floras of the northern and southern counties differ widely, but how much is due to the nature of the soil and to water, and what is strictly owing to differences in heat cannot be determined as yet with accuracy.

Following the isothermal lines of our State westward they diverge widely. The lines for the summers on our coast correspond with those for northern and central New York, and the region of the Great Lakes, while those of the Delaware bay belt correspond with the valley of the Ohio and southern Missouri. The isocheimal, or winter lines of the coast and of the southern end of the State also bend southward, and follow the same general direction as the

*According to 13 years observations at Perth Amboy, (1819-1831), the mean date of blossoming of peach was April 21st, and of apple May 2d. Thirteen years observed at Lambertville (1840-1855), gave the mean dates of April 14th for peach, and April 26th for apple.—*Blodgett's Climatology*, *p.* 507.

Observations for same years (1841-1857, inclusive), at both places show similar differences of 0 to 13 days in blossoming of peach, cherry and apple.

PLATE I.


Mean Annual Curves of Temperature
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I. Kittatiny Valley and the Highlands
II. Red Sandstone Plain
III. Southern Interior
IV. Atlantic Coast Belt
V. Delaware Belt
VI. Peninsula of Cape May
Julius Bien, lith

isotherals, or summer lines. This general deflection to the south is evidence of our milder climate than that of the same parallels of latitude to the west of our borders, while the northward turn of the summer lines of the coast region indicate the influence of the waters of the ocean in that part of the State.

I.—THE KITTATINNY VALLEY AND THE HIGHLANDS.

This province comprises the Highlands and its included valleys, the great Kittatinny valley and all the country northwest to the Delaware river. The Ringwood, the Rockaway valleys, the valley of West Milford, Berkshire and Longwood valleys, Succasunna Plains, German valley, the Musconetcong, Pohatcong and Pequest valleys are embraced within its limits. In short, this division is that part of the State which belongs to the great Appalachian chain. Its limits are defined by the colors of the map which represent the areas of the Archaean, Silurian and Devonian rocks. They cover 1,460 square miles, or one-fifth of the State. The geological structure explains the configuration and to some extent its nature also. The Archaean gneisses, granites and crystalline limestones make up the Highland mountain ranges; the valleys are occupied by blue limestones, slates and drifts. The general course of the mountain ranges and the valleys is northeast and southwest. And the drainage is through the valleys, southwest into the Delaware river and northeast into streams which empty into the Hudson. The crests of the mountains are from 300 to 600 feet higher than the valleys, and the ranges increase in height from southeast to the northwest, and also from the Delaware river towards the New York line. The Hamburgh mountain is 1,488 feet high, and Scott's mountain 1,277 feet. The most southeasterly ranges are from 900 to 1,200 feet high. Taken as one plateau, or table land, there is a gentle descent (of about 30 feet to the mile,) towards the southeast. The valleys interrupt the continuity of the surface so that there are no broad, elevated plateaus, although Scott's mountain, in Warren county, and the Schooley's mountain range, as continued in Sussex county, may be considered as such. The first is about nine miles long and three miles wide, and from 1,000 to 1,200 feet high; the latter is nearly thirty miles long and from two to five miles wide, and varies from 900 to 1,500 feet in height. Budd's lake, Lake Hopatcong and Wawayanda lake lie in basins on it. There are other smaller areas of nearly the same height, and the whole district of the Highlands may be considered as a table land, from 900 to 1,500 feet high, since the included valleys are narrow, excepting towards the southwest, near the Delaware.

The Kittatinny valley is the broad valley between the Highlands and the Kittatinny or Blue mountain. It is a part of the great valley which extends from Canada to Tennessee, known by various local names. In New Jersey its surface is much diversified by drift hills and slate ridges, which rise above the lower limestone bottom and make subordinate and lesser valleys. Its length is thirty-nine miles and its average breadth ten miles. It is noted for its fertile soil, its beautiful landscapes and its wealth. Its greatest elevation is in some of the slate ridges in Sussex county, which are about 900 feet high above ocean level. The greatest depressions are at Belvidere, where the river is 235 feet, and at the Wallkill, where it enters New York State, 383 feet above tide.

The Kittatinny or Blue mountain, which bounds the valley on the northwest, is a narrow mountain range, stretching entirely across the State, and rising to the height of 1,474 feet at the Delaware Water Gap, and to 1,800 feet in High Point, near the New York line—the highest ground in the State. Its eastern slope is very steep and throughout much of the length it is precipitous; the western is more gentle. Between this mountain and the Delaware there is a narrow valley, whose height is 297 feet at the Water Gap and 390 feet at Carpenter's Point, corresponding closely to the elevation of the Kittatinny valley.

The surface of the Highlands at the southwest, in Hunterdon and in parts of Warren and of Morris counties, is marked by its smooth and uniform slopes, and it is largely in farms and under cultivation, whereas to the northeast, in Sussex and in Passaic, and, in general, north of the line of the terminal moraine, the glacial effect has been such as to leave it much more uneven and rocky, and consequently unsuitable for easy cultivation. And probably 75 per cent. of its area there is still in forest. The drainage of that portion lying to the south of the drift line is rapid, and there are no large tracts of wet or swampy lands as are found north of it. For a description of the marked differences of surface features between these sections of the Highlands, the reader is referred to the last annual report of the Geological Survey.

In the Kittatinny valley the surface is very generally cultivated.

and in farms. A careful estimate makes the cleared lands about three-fourths of the whole area. The forest consists of some large tracts of wet, swampy lands, and many detached lots and small groves. The valley of the Delaware, northwest of the Kittatinny mountain, is less cleared up, but the larger part is in farm lands. In both of these valleys a very large part of the whole farm area is in meadow, or grass land, as it is a noted dairy country.

The Kittatinny mountain, separating these valleys, remains an almost unbroken forest belt. On account of its numerous and extensive outcropping ledges of hard, gritty rocks, and its thin, stony soil, it is covered by a stunted forest growth of yellow pine, scrubby oaks, with scattering maples, chestnuts and hemlocks.

These diversities of surface, both natural, and those which have their origin in the clearing and in the cultivation of the country; the differences of elevation; and, further, the configuration or shape of the valleys, all tend to produce differences of climate, although scarcely to be detected among our few and short series of observations. As stated in the introduction, other things being equal, the mean temperature decreases about one degree for every 300 feet of increase in height. Applying this rule we should expect to find that of the Highlands about 2° below that of the Kittatinny and other valleys, which are included among the Highlands. And at the same rate of decrease the crest of the Kittatinny mountain would have a mean temperature of 3° or 4° below the valleys on either side. That it is more exposed to the wind and sensibly cooler, is well known and observed by the visitors to the Delaware Water Gap and to High Point.* But the range is so narrow that the warm currents of the day cannot be cooled very much in their rapid passage up its comparatively short slopes and over its crest. The westerly winds coming from off the more wooded and mountainous country to the north and west are probably less heated than the same currents are after their passage across the Kittatinny valley. The differences are no doubt greater, *as felt*, than instruments would record. The earlier snowfalls at the beginning of winter show that there is some difference. The snow-covered crest is a common phenomenon to the inhabitants of the valley when that is yet bare.

The valley of the Delaware, from Port Jervis to the Water Gap, experiences high summer temperatures, although we have no records

*The same range as it continues in New York State, and is known as Shawangunk mountain, is found to be somewhat cooler than the valley on the south. Observations at the noted summer resorts of Lakes Mohonk and Minnewaski, in Ulster county, show it.

excepting the short one kept by Charles F. Van Inwegen, A.M., at Port Jervis, to give us the comparative figures. The mean or average for the summer may be slightly cooler than the Kittatinny valley. This valley is much visited by tourists in the summer and autumn, who seek comfort, pleasure and health in its attractive localities. The beautiful and wild scenery, and the fishing and hunting, for all of which it is noted, divert the attention so that the extremes which are sometimes reported are not felt seriously. The greater coolness of the nights, especially in the summer, as compared with that of our cities near the sea-board, enable one to endure the same extremes by day with much more comfort. In consequence of the short period covered by the Port Jervis record, which we use as representative of this valley, it has been carefully compared with that of Newark for the same period, and then reduced so as to correspond to a term of the same length—that is, 38 years. This comparison shows that in the winter months Port Jervis is 4° to 6° colder than Newark; and in the summer it is 3° to 5° cooler. The mean annual temperature is 4.33° colder than that of Newark, and 5.5° below the mean for New York city. But the extreme range of temperature is greater at Port Jervis, and, judging by the comparative records, amounts to 8° or 10°. And it is made by the lower winter extremes. The maximum of the summer is about as high as in Newark or in New York city. The mean annual and seasonal temperatures as thus obtained, are—

Spring	44 53°
Summer	66.68°
Autumn	47.83°
Winter	25 74°
Year	46.19°

The yearly mean is a little below that given for this valley in Blodgett's Climatological Map of Pennsylvania, in Walling's Atlas of that State. A longer series of observations may alter these figures slightly.

No meteorological observations are known to have been kept on the Kittatinny or Blue mountain, excepting at the U. S. C. station at Culver's Gap, in Sussex county, where tri-daily observations on temperature were made from August 19th to September 29th, 1881, by A. A. Titsworth, M. S. In that time a maximum of 102° was reached (the thermometer hanging in the shade in the open air) on the 7th of September. The minimum and the daily means differ but little from those recorded by Mr. Whitehead, at Newark. But no conclusions about mean temperature can be drawn from this record. The night and morning hours in still weather on this crest would probably give higher readings than the valleys on each side, in consequence of the colder and denser strata of air settling in these valleys, leaving the warmer air about the mountain tops.

In the Kittatinny valley and the Highlands we have records at the following localities :

Deckertown, Sussex county, 7 months.......... ....A. C. Noble.
Newton, Sussex county, 8 months..........................Dr. Thomas Ryerson.
Dodge Mine, Morris county, 1 year 2 months.............Wm. Allen Smith.
Dover, Morris county, 2 years 4 months.................. H. Shriver.
Mount Olive, Morris county, 4 months.....................A. A. Titsworth.

The periods covered by these records are so short that it has seemed necessary to add to them that of Goshen, Orange county, N. Y., which is 11 years in length, and that of Easton, Pa., 5 years long. Goshen is 12 miles from the State line, but the valley there has the same general features as in Sussex county, and hence it seems fair to assume that it is representative of the northern part of *our* Kittatinny valley. Easton is at the extreme southwest, separated by the river only from our territory. It may stand for the lower or southwest parts of our Musconetcong and Pohatcong valleys as well as the Kittatinny valley. The average of the two places may give the mean temperatures for our valleys. The range at Goshen runs to a low extreme. The station at the Dodge Mine is one of the highest, and its location on a plateau of the Highlands makes it a good one to represent that part of the State. It has been compared with Newark and reduced by difference to correspond for a like period of 38 years. The record for Easton has also been compared and reduced. West Point's long series, extending through 46 years, has been put in the table for purposes of comparison, but its position on the Hudson, nearly at tide level, gives it some peculiar features which are not altogether common to the climates of our Highland valleys. It becomes, however, a kind of check upon our short series at the Dodge Mine. Comparing Goshen and the latter, we observe that the mean temperatures for the Winter months are nearly alike. The differences in the Summer and Autumn are small, but in the Spring the Dodge Mine record runs three degrees below that of

Goshen. It is probable that the later melting of the Winter's snows in the wooded mountain district in which this station is situated makes this difference. The close correspondence throughout the year between the latter and Port Jervis are remarkable and suggestive. And these three records may represent the extreme northern part of the State, while the more southern valleys are represented by that of Easton. As compared with Newark, the mean annual temperature is three to four and a half degrees lower. The greatest monthly difference appears in March, amounting to about six degrees. The average between the three places for the year, is 46.5 degrees. The isothermal of 46.5 degrees runs, according to Blodgett's map of Pennsylvania, through the northern part of that State. The relation of the several places to one another, in temperature, by months and by seasons, is shown in Plate II. The table of mean temperature gives the figures for the several stations for like periods. In the Table of Temperature the extremes also are given for months and for the year. But with the exception of Goshen, the extremes are not of much importance, and the ranges are too short, since the records are not long enough to exhibit the greatest extremes of either heat or cold. They may be regarded as approximations which further observations may change slightly.

In general, the climate of the Highlands is not marked by excessive extremes of temperature. The spring opens a few days later than it does in the valleys and on the red sandstone plain, but it advances rapidly so that May is nearly as warm, and vegetation on the first of June is quite as forward, as on the lower lands.* The summer is not marked by so great extremes of heat, and hence the hot weather is much more endurable. The attractiveness of Schooley's mountain, Budd's Lake, Lake Hopatcong, Newfoundland and Chester, is no doubt greatly owing to the absence of excessively high temperature in midsummer. But more marked are the lower night temperatures, and all travelers and tourists going from our cities into the Highlands notice the cooler and more refreshing nights, and thereby experience the relief which comes from such a delightful change. In the winter the lowest temperatures are but little below those observed in Newark and the central part of the State, although the average minimum may run uniformly lower than in the latter. It is said by observers of the weather that the extremely low winter

*On Schooley's mountain the spring is 5 to 8 days later than it is in the Musconetcong valley, and the wheat and rye harvests are nearly as much later.—*Wm. W. Marsh, of Schooley's Mountain.*

temperatures on the hills are often several degrees above what is recorded at such times in the adjacent valleys. This striking phenomenon has been particularly observed on Schooley's mountain, which has the deep German and Musconetcong valleys on its sides. Such phenomena accord with what has been observed elsewhere in mountainous countries, and they harmonize with the explanation given on a preceding page in reference to the Kittatinny mountain. The frosts come later in autumn on the hills and ridges of the Highlands than they do in the valleys. But the low and wet swampy depressions among the hills, especially north of the terminal moraine, are not thus favored. This exemption from frost is more marked to the southwest, in Hunterdon and Warren counties and the southern part of Morris county. In some of the wet localities in Sussex county frosts have been known to occur in August. But generally there are none which injure vegetation much before October. And in some years severe frosts are not experienced before the first of November. The most remarkable and striking difference between the Highlands and the red sandstone plain, to the south and east of them, is the earlier appearance of snow in the late autumn or at the beginning of winter. The same storm bringing rain to the latter, covers the higher mountain ranges with snow. This first coming of snow is often a fortnight earlier.* And the sleighing season begins earlier and continues later than it does in the central or eastern parts of the State. Even between Schooley's mountain and Hackettstown there is often all the difference between good sleighing and roads bare of snow. From New Brunswick we can frequently note a like difference between the bare shale of the Raritan valley, and the snow-covered Chester and Fox hills ranges in the northwestern horizon. As the weather grows colder this distinctive mark is obliterated by the winter storms, which sweep over the whole country and envelop all alike in snow.

In the winter the cold is not sensibly greater than in the lowlands, although the minima recorded at Goshen and Easton run several degrees below those of Newark, New Brunswick and Trenton. And this is true in the face of much longer periods at the latter places, giving opportunity for lower extremes. The West Point series, so much longer, appears to confirm the occurrence of low winter temperatures. And it may be substituted for our Highland valleys.

*This year (1881) the first snow on the Highlands and on the Kittatinny or Blue mountain fell November 4th; the first on the red sandstone plain (southeast border) was December 15th—a difference of nearly seven weeks.

The northeast and southwest courses of these valleys in a measure protect them and permit the free movement of warm, southwest currents of air through them, far into the Highlands. The northwest sides of the valleys are sheltered, as it were, by the steep hills and mountains to the west of them. The southern slopes are better exposed to the action of the sun's rays, and thereby more quickly warmed than those to the north. The greater depth of the snow in the spring, on the northerly mountain slopes, shows the less active melting influence of the sun on that side of the hills generally.

The well-drained surface of the more southern part of the Highlands, and the more porous and drier gneissic soils must have some influence upon the humidity and the temperature of the air, and upon the general healthfulness of the country. Then, again, the greater proportion of cultivated area as compared with forest, contributes to heighten the working of the surface so well drained, and tends to make the climate drier. To the north of the terminal moraine line there is much more wet and swampy land and a much greater area covered by forest. These unite in making the air more damp, and their effect is, as has been stated in the introduction, to lower the temperature slightly.

It is unfortunate that we have so few meteorological stations in this part of the State, since it would be of great interest and of public importance to show by figures the differences which are here indicated by general statements only.* And not only to demonstrate these positions, but to exhibit the features of climate, which make the Highlands so attractive for tourists and for rural homes and retreats, and so comfortable and health-giving to both the natives, and also to the invalids who seek strength and health on these hills.

* Since writing the above, Rev. S. W. Knipe, of Delaware Water Gap, Pa., has contributed the following results of his observations for the years 1879–1881, inclusive, at that place:

MAXIMUM AND MINIMUM TEMPERATURES. DELAWARE WATER GAP, PA.

	Jan.		Feb.		Mar		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
Year.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1879	55	-14	48	0	60	15	62	22	80	30	87	42	97	48	95	47	85	32	90	22	80	10	56	0
1880	56	5	60	-4	70	15	75	22	82	31	92	47	96	48	90	45	97	42	70	27	60	5	48	-10
1881	40	-18	46	-9	59	21	70	17	85	32	84	43	98	54	101	46	102	48	78	29	65	20	65	15

These figures show a considerable range of temperature and low extremes in the winter months, comparable with those of the Port Jervis record.

II.—THE RED SANDSTONE PLAIN.

The red sandstone plain appears on the map colored dark red. The trap-rock ridges are of a greenish gray shade. This geological formation is 70 miles long, from the New York line to the Delaware river, and is 15 miles wide on the former and 30 miles from Milford to Trenton, along the Delaware. Its area is estimated to be 1,540 square miles. When compared with the Highlands, which bound it on the north and west, it is a great plain. But its surface is not altogether that of a plain, for it is diversified by gently swelling ridges, and is traversed by abrupt ranges of trap-rock, which stand out quite prominently above the general level of the red sandstone country. They divide it so as to form subordinate or lesser valleys. In Hunterdon county, between the South Branch and the Delaware, there is an elevated district, or table land. The Upper Passaic valley is shut in by the ranges of trap-rock. But at present the meteorological records are not full enough, nor are our stations so distributed as to allow of a subdivision which this configuration of the surface suggests. It is here made one climatic division or province of the State.

The general drainage of the whole belt is to the south and southeast, through the Hackensack, Passaic and Raritan rivers and their tributaries; and to the southwest, by many small streams, into the Delaware. The general slope is southward, from the foot of the Highlands, where the elevation is 300 to 400 feet, to tide level, on the south and southeast. The valley of the Upper Passaic is lowest near the trap-rock ridges, on its southeast border, and it is there 160 to 180 feet high. The trap-rock ridges are very prominent in the northern part of the plain, and they rise 200 to 500 feet above it, culminating in High mountain, at an elevation of 879 feet, and in the Watchung mountains at 691 feet. They are rough, rocky and largely covered by forest. The Palisade mountain, separating the valley of the Hackensack from the Hudson, rises gradually going north from Jersey City, and is 300–522 feet high from Fort Lee to the State line. Its crest is still to a great extent wooded. The average height above tide level of a large part of this division of the State, within the limits of Bergen, Essex, Union and Middlesex counties, does not exceed 100 feet. The northern portion of Bergen is undulating, but its ridges do not seem to have any effect upon the climate. The difference of elevation between the Upper Passaic valley and the trap-rock ridges on the one side and the low plain to the east of the latter, has, probably, a slight effect upon the temperature and upon the rainfall. And it may correspond somewhat to that between the Highlands and the valleys as stated above.

In the absence of any long records in this valley, or on any of the mountain ranges, it is not possible to express by figures the differences of temperature in the several parts of this province. It is noticed in the frosts and in the early winter snows which whiten the hills, when the plain to the east is still bare. Certain it is that the residents of Madison, Caldwell and Orange Mountain believe that their rural homes are more comfortable during the hot weather than residences in Newark or New York. But the more open situations in the country, which allow a free circulation of the air, are an advantage which may offset mere temperature. The measurement of the total air movement, or the winds, would show a great difference in favor of these hills. The greater percentage of area in forest on the trap-rock ridges also exerts an ameliorating effect in the warmer months. The hot, southerly winds, striking the mountain tops and passing over woodland whose soil is not parched and dried up by long-continued drought and heat, are sensibly cooled.

The country to the west and southwest of the Watchung mountain ranges, and which is drained by the Raritan, is a low-lying plain, almost bare of timber, and it is, consequently, exposed to both the full sweep of the winds, and to the heating effect of the sun's rays. It is subject to the extreme temperatures of the summer, whilst the greater part of it is too far from the ocean to enjoy its equalizing influences. The records of New Brunswick and Trenton give high summer temperatures, not exceeded by any other records in our table. The remarkably large area almost entirely destitute of forest, and the quick-drying shale and sandstone soils allow of an accumulation of heat in them. And it seems as if there was some connection between the soil and the lateness of the frosts in autumn, which keep off longer than they do in the Highlands and the Kittatinny valley. The mean difference in temperature due to this bared condition of the country can amount to 1.3°, as mentioned above.

West of the South Branch and north of Flemington there is a table land 500 to 800 feet high, and occupying an area of nearly 150 square miles. The Delaware flows along its southwest border, or, more properly, it may be said to flow through it, as the elevated country continues westward into Pennsylvania, and the river has eroded a deep canon-like valley through it from above Milford to Lambertville. Such an average height must reduce the mean temperature at least 1°, as compared with Lambertville and Trenton, or other localities in the lower surrounding country. But we possess no meteorological records from it.*

The red sandstone plain has a well-drained and naturally dry soil, excepting in the Upper Passaic valley, where there are extensive tracts of wet meadows and swamps, and some smaller areas of wet lands in Union county. These are all north of the terminal moraine line. There is also more forest, in proportion to the whole surface, in the country to the north of the same line than in the central or western parts. The trap-rock soils are all cold, and generally wet, even when cleared and cultivated. The effect of these variations in the soil, though slight, cannot be wholly ignored. They are capable of measurement in the Upper Passaic valley, and on the Watchung mountains, if not elsewhere.

The varying distances from the ocean also have their influence. The records of Bloomfield, Newark and South Orange, when compared month by month with New Brunswick, Somerville and New Germantown, show the more even temperatures at the former, amounting to a little over 1° for the autumn and winter, whereas in the spring and summer the variation is reduced to a minimum.

These disturbing or modifying elements in the several parts of this province or division of the State are not so marked in their results that we can do more than indicate a probable further subdivision, according to the well-marked natural lines mentioned above. But, for convenience of reference, the localities or stations are placed in two groups; the first embracing all in the northeastern,

* Prof. C. W. Larison, M. D., of Ringoes, Hunterdon county, has started recently two records at localities on this plateau, with a view to ascertaining its peculiarities as compared with those of Ringoes.

The records of extreme temperatures at Ringoes, kept by Dr. Larison, give the following extremes, as observed in the several months:

Jan.		Feb.		Mar.		Apr.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.	
Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
66	-17	73	-3	70	4	85	18	92	30	103	40	102	50	101	46	104	35	92	20	74	6	65	-11

The maximum for the period observed (from January, 1873, to December, 1881, inclusive,) was 104°, and the minimum temperature was -17°, making a range of 121°. The greatest range in any one year was 116°, in 1881. The least was 95°, in 1878. The greatest range in any month was 67°. The period of observation includes the years 1873, '74, '75, '76, '77, '78, '79, '80 and '81. The observing hours were 6 A. M. and 1 P. M. The above extremes for the months should have been inserted in the table of temperature, but owing to their late reception it was not possible to include them.

and the second all those of the central and western parts of this belt. The records of observations kept in New York City, at Fort Columbus on Governor's Island in New York harbor, and in Jersey City, are placed together. The first and second are long series, and are desirable for comparison. They represent the tide-water border of this *province*. For the list of stations, with their elevation and length of observing period, as also names of the observers, reference must be had to the folded table of temperature. The greater number of stations and their long series, as compared with the scanty records of the Highlands, are noteworthy. But this is the densely populated belt of the State, and there are living on it 650,000 inhabitants, or more than half of the people of our State. Its climate affects the majority of our population, and hence the importance of records from so many localities.

The mean temperature, by months and seasons, at the several stations, together with the maximum and minimum for the months and year, are given in Table of Temperature. And a graphical representation of Newark, New Brunswick, New Germantown, Princeton, Lambertville and Trenton appears on Plate I. The mean for the province is obtained by using the mean temperatures of these six stations. The seasonal and annual means are:

Spring	48.40°
Summer	71.35°
Autumn	52.63°
Winter	30.03°
Year	50.60°

The figures for the several stations vary from one another to the extent of about two degrees, excepting, however, from this comparison, the record for Trenton, which appears to have a somewhat higher average than surrounding stations would indicate for it. Thus, New Germantown, near the northwest border, has a lower mean annual temperature than the eastern stations. And the difference comes from the autumn and winter months mainly. The cold seems to be more severe here than elsewhere recorded. There is a notable difference between Newark and Princeton, also. The mean temperature at the latter place runs below that of Newark, 1.5° for the year, but the range of temperature is four to five degrees greater. The long record at Lambertville shows a close correspondence, both for the months and the seasons, with that of Newark, but the annual range is 121.5°, and the greatest monthly range 86.5°, as compared with 111.25° and 77° at Newark. The Trenton record varies from one to three and a half degrees above that of Lambertville. And the very long series of observations at Morrisville, on the opposite side of the river, gives a mean for the year of 51.75°, or one and a half degrees below that of Trenton. The variations between these records are not uniform throughout the year, but are greater in the winter than in the summer months; they suggest, what may be possible, that the mean winter temperature at Trenton is about two degrees above that of Newark or New Brunswick. The situation of Trenton, on the bend of the river, where it is wide and curved, so that the winds from the northwest and southwest pass over a greater length of water than the actual river breadth, may have something to do with the higher winter temperatures. The more tender vegetation and some varieties of the ivy appear to thrive better here than eastward, at New Brunswick, for example.

The climate of this belt, so far as temperature is concerned, approaches nearest to what may be considered an average of the State. There is greater uniformity of surface than in that of the Highlands, and there is less forest in proportion to the whole area, than in any other division of the State. The range of temperature for the year, is, however, larger than in the other climatic provinces, stretching from 22° below zero to 103° above, or 125° for the year. These figures are the results derived from long series of observations stretching over 43 years, whilst in the other parts of the State we are confined to much shorter periods. The monthly variations also are wide, and ranges of 70° in a given month have been recorded. March generally affords the greatest extremes, owing to sudden warm periods of short duration, when the thermometer reaches an unusually high maximum. The winter months also have wide ranges, due to extremes in both directions from the mean temperature. While there are these high monthly ranges, the climate is not excessive. The winters are less severe than they are in the Highlands, and are not quite so long. And occasionally they are very mild, and the ground is unfrozen and the streams are free from ice, even in midwinter. The cold weather usually comes about the holidays, and is accompanied with the formation of thick ice and snow. A common phenomenon is the "January thaw," which may be termed a period of a week or ten days of mild weather, when the frost disappears almost entirely from the ground and ice breaks up in the streams, giving rise to freshets. The examination of long continued observations have so far failed to detect any regularity in the occurrence of such a *warm spell.* All that can be said of it is that it is not uncommon. The coldest weather occurs most generally in January and near the middle of the month, but to this rule there are many exceptions. In the last winter the *cold day* was the last of December. The winter may be said to continue until the middle of March. The advance of the spring is generally slow until the latter part of April or first of May. But from that time onward it is rapid. Both the spring and the autumn are shorter than our calendar seasons. And the more natural divisions of the year for all the central part of the State would be, winter until the vernal equinox, three and one-half months; spring, until June, two and a half months; summer, until near the autumnal equinox, or to the middle of September, three and a half months; then Autumn, until first of December. The cold and hot seasons cover more than one-half of the year. A reference to the diagram, Plate I. will illustrate this statement. The period free from frosts, or what may be termed the growing season, often continues quite into October, and sometimes to November. Frosts have been known earlier, as in such an exceptional year as that of 1816. But the three summer months are, practically, exempt from any frost. The winter usually begins about the first of December, when the ground begins to freeze and ice is formed. In November there is a variable period of warm and smoky weather, which is known as "Indian summer," apparently due to smoke from forest fires in the more wooded districts to the north and northwest. The subject of its occurrence has been studied elsewhere, and at Toronto, in Canada, a long series of observations appears to show that its occurrence is limited to the period of October 5th to November 23d, generally coming October 27th to November 2d, and lasting six and a half days. Here, in this belt, as in the northern and also in the southern interior belts or provinces, the so-called "Indian summer" is always anticipated, although the cold preceding it may have the semblance of early winter. Snow sufficient for sleighing, for a short period at least, occurs every winter. In this particular the belt marks a transition from the Highlands, where *sleighing snows* mark every winter, to the southern interior, where there may pass a winter without sleighing. That of 1879 and '80 was remarkable for its slight depth of snow and its generally warm weather. Reference to the historical notes and to the table of temperature and diagrams for the weather at Newark, show how rare such seasons are.

The appended table of the climate of Newark gives, in a compact form, the more prominent features of the climate of this belt. The variations in the *maximum* and in the *minimum* temperatures for the several months, in the range of temperature observed, in the highest and lowest mean monthly temperatures, the number of days on which the average was 32° and below, and 85° and upwards, the number of fair, rainy and snowy days, and the range of dry periods, are all given.

CLIMATE OF NEWARK, 1843–1880.—From Record kept by WM. A. WHITEHEAD.

	Maximum Temperature.		Minimum Temperature.		Range of Temperature for Period.	Mean Temperature.		Greatest Number Days on which Temperature was 32° and below.	Greatest Number Days on which Temperature was 85° and upwards.	Range of Fair Days		Rainy Days.		Days of Snow.		Average Number of Fair Days.	Percentage of Fair Days.	Range of Dry Periods. Days.	
	Highest.	Lowest.	Highest.	Lowest.		Highest.	Lowest.			Greatest Number.	Least Number.	Greatest Number.	Least Number.	Greatest Number.	Least Number.			Longest.	Shortest.
January	65.00	37.00	15.50	-12.50	77.70	37.64	19.33	22		21	13	11	1	12	1	17.00	55	15	5
February	68.50	44.70	15.25	-8.00	76.50	36.99	21.86	18		21	12	11	1	13	2	16.50	58	14	4
March	77.25	50.00	26.00	2.00	75.25	46.17	30.23	7		23	13	16	2	11	1	18.00	58	16	5
April	85.50	62.25	40.00	17.00	68.50	55.55	41.48			23	12	13	5	9		17.50	58	15	3
May	96.00	71.00	42.50	31.00	65.00	68.38	54.72		8	25	12	17	5	2		18.70	60	14	4
June	97.00	84.00	57.50	38.25	58.75	73.70	60.25		11	26	15	15	5			20.50	68	20	3
July	99.75	86.25	62.50	46.25	53.50	78.31	70.23		24	25	14	15	4			19.75	64	15	6
August	99.00	83.75	60.00	46.75	52.25	74.75	67.30		20	26	14	15	5			19.75	64	20	5
September	*93.75	76.50	48.00	34.50	59.25	†68.64	59.98		‡6	24	12	14	3			18.75	62	21	3
October	83.00	67.00	35.75	22.25	60.75	59.40	48.61	6		24	12	12	3	2		18.00	58	29	3
November	73.75	57.25	28.50	8.00	65.75	49.66	36.12	21		22	10	15	4	10		16.00	53	18	3
December	68.50	42.00	22.75	-7.50	76.00	40.31	23.81	28		24	11	13	2	10	1	17.00	55	24	3
Spring						53.81	45.13												
Summer						75.34	68.12												
Autumn						§56.32	50.77												
Winter						35.91	24.81												

*September, 1881, maximum was 100.5°.
†September, 1881, mean was 73.72°.
‡September, 1881, 85° and upwards on 11 days.
§Autumn of 1881, mean temperature was 58.77°.

III.—THE SOUTHERN INTERIOR.

In the northern half of the State the geological structure is the basis for our climatic divisions. In the southern part the nearness to the waters of the ocean on the east, and to the Delaware bay on the west and southwest, exerts a modifying influence, and the elevations above ocean level are comparatively so inconsiderable that they may be disregarded altogether. The nature of the surface and the character and extent of the forest disturb but slightly the climate, as determined by latitude, by proximity to the sea and by prevailing winds.

The southern part of the State has been divided into what appear to be four natural divisions or climatic provinces, in conformity with the geography, and attested by meteorological records at numerous stations. The first of these to be described is known as the Southern Interior. And it comprises much the greater portion of South Jersey. Its limits cannot be accurately located, as it grades insensibly into the adjacent divisions or belts of the Atlantic coast and of Delaware bay. Its area is roughly estimated to be 3600 square miles. Like the other provinces, already described, it is capable of subdivision, and the differences in mean temperature, recorded at Freehold and the Burlington county stations, and those observed at the more southern localities, as at Atco and Vineland, indicate a northern and a southern grouping of these stations and an east and west division line. But our records are still too incomplete to indicate its accurate location. The southern interior constitutes the southern water-shed, and the greater breadth of the Atlantic and of the Delaware river slopes. The drainage is by streams, which do not follow valleys determined by geological structure, but which seek the most direct courses to their respective outlets. The average height above the ocean varies from 200 feet along its central axis to the tide-waters of its streams.

Geologically, the greater part of the green-sand marl district, the larger area of the oak lands, and all of the pine-land belts are in it. There are no rocky outcrops, nor steep slopes, as are found in the northern divisions. And the elevations cannot have any appreciable effect upon the temperature. The surface may be said to be generally sandy. And the pine-land belts include broad areas where the surface is a glistening white sand, on which there is a very scanty growth of pitch pine (*P. rigida*), and scattering, scrubby oaks. The geological map shows, by its green colors, the marl belt, including the red sand bed outcrop; by its yellow-striped areas, the oak lands; and by solid yellow color, these pine lands. The older descriptions termed the latter "pine barrens." The poverty of the soil is evident in the timber growing on it. The general influence of soil and forests have been mentioned in the introduction and referred to in the descriptions of the Highlands and of the Red Sandstone Plain. In this province their influence is more marked than to the northward, on account of their striking peculiarities. And it is most evident in the temperature of localities. The conductive power of such soils and land surfaces are such that they become intensely heated by the sun's rays falling directly upon them, and both more rapidly as well as to a greater depth than more clayey and grass-covered soils. In short, they are *warm soils*. They often become so hot in the heat of the day as to be almost unbearable to the touch of the bare foot or hand. The stratum of air in contact with so hot a surface is also heated, and in this way the lower atmosphere is raised to a higher temperature than it would be over a cold, wet soil, or over water. The influence of such a sandy soil is both heating and drying, and somewhat like that of a desert, making the days hot and the nights, owing to rapid radiation of the heat, cool, and producing a wide daily range. Hence, also, the occurrence of frosts late in the spring and early in the autumn also. The heat of the day forces vegetation forward early in the spring and then the cold of the night may bring frost to kill it.* While the influence of so sandy a surface is greatest in the pine-land belts, it is felt throughout this whole division to some extent. The observations at Atco and Vineland show something of the extremes of temperature, although the averages of the daily range would be more expressive of their extent. As it is, the range of temperature during the year varies from 98° to 116° at given localities, or to 121° for this whole province. The present year (1881) gives 102° and 104° as maxima for September,† and within one month there was a fall of 84° at several of the stations.

The mean temperature also runs high in the summer, particularly at Atco and Vineland. That of the winter is not correspondingly so

*A remarkable instance of late frost occurred in the beginning of summer, June 6th, 1878, which was felt in Ocean and Burlington counties severely. The tender oak leaves were killed and fell off and were succeeded by a second growth, giving to the forests a strangely unseasonable appearance.

†September 7th, 102° at Freehold; 104° at Vineland.

much higher, as compared with like seasons in the northern half of the State. The averages of the mean temperatures, by seasons and for the year, at Freehold, Burlington, Mount Holly, Moorestown, Haddonfield, Atco, Vineland and Philadelphia (included because of its length of period), aggregating a term of 131.5 years, is as follows:

Spring	49.83°
Summer	72.96°
Autumn	53.95°
Winter	31.93°
Year	52.05°

Curve III. of the diagram, Plate I., shows the movement of heat for the year, through the several months, as compared with the other provinces of the State.

The climate of this large division varies a little from north to south, being warmer at the southwest, and also from east to west, but these variations are confined within narrow limits. The observations at Freehold show in general a lower temperature for all the months than that of any of the other stations. It is possible that the difference is that corresponding to that of latitude alone. Along the Delaware river from Bordentown down, there is a very narrow strip of country which is influenced by the proximity of the river. The prevailing west and southwest winds, as they sweep across it, are no doubt slightly cooled by it in the summer and autumn months, while later in the season the presence of such a body of water tends to raise the temperature. On account of its soil it is noted for its adaptation to the production of early vegetables and small fruits. And truck farmers say that within a short distance of the river the frosts are not so late in spring, and *keep off* later in the autumn than they do further from it. In general, the climate differs little from that of the Red Sandstone Plain, described above. The seasons are all from one to two degrees warmer, with the greater difference in the winter, owing to the equalizing effect of the greater nearness to the ocean. There is less snow on the average, and the ground is bared sooner by the more rapid melting. The winter of 1880–81 was, however, an exception, and the snow-fall in Monmouth county, was nearly twice the depth of that in the northern part of the State. For the details of localities the reader is referred to the table further on, which gives the mean maximum and minimum temperatures by months at the several localities in this climatic province.

The following tables, from the records of Thomas J. Beans, at Moorestown, in Burlington county, and of Dr. John Ingram, at Vineland, in Cumberland county, showing the late and early frost dates and the periods between frosts, are here inserted as bearing upon these important phenomena of climate. The observations at Moorestown are from 1865 to 1880, inclusive; those of Dr. Ingram extend over fifteen years—from 1866 to end of 1880. They fairly represent the division of the Southern interior. The average length of the season at Moorestown is 179.6 days, or about six months. The Vineland table shows the severity of the winter also. And both indicate June, July, August and September as the warmer months, free from all frosts.

TABLE OF FROSTS.

By THOMAS J. BEANS, Observer, Moorestown, N. J.

YEAR.	FROSTS INJURING TENDER VEGETATION.		Length of Season.
	Latest in Spring.	Earliest in Autumn.	
	Date.	Date.	Days.
1865	April 14	October 14	186
1866	May 15	October 5	143
1867	May 14	October 25	174
1868	April 24	October 17	176
1869	April 15	October 21	189
1870	April 20	November 8	202
1871	April 18	October 21	186
1872	April 23	October 29	189
1873	April 13	October 26	196
1874	April 30	October 15	168
1875	April 25	October 13	171
1876	April 26	October 12	169
1877	April 15	November 4	203
1878	April 17	October 22	188
1879	May 10	October 29	164
1880	May 1	October 19	170
Range	April 13 May 15	October 5 November 8	203 143
Means	....	....	179.6

TABLE OF FROSTS.

By Dr. J. Ingram, Observer, Vineland, N. J.

YEAR.	JAN. Days. Some Frost.	JAN. Days. All Frost.	FEB. Days. Some Frost.	FEB. Days. All Frost.	MAR. Days. Some Frost.	MAR. Days. All Frost.	APR. Days. Some Frost.	APR. Days. All Frost.	OCT. Days. Some Frost.	OCT. Days. All Frost.	NOV. Days. Some Frost.	NOV. Days. All Frost.	DEC. Days. Some Frost.	DEC. Days. All Frost.	YEAR. Some Frost.	YEAR. All Frost.
1866	21	5	20	4	15	...	3	...	1	...	10	...	23	13	93	22
1867	29	22	10	2	14	3	...	...	3	...	9	...	26	11	91	38
1868	26	13	28	17	14	4	5	...	4	...	10	...	26	11	113	45
1869	22	4	17	4	19	5	...	...	5	...	16	...	22	3	101	16
1870	12	2	23	4	16	3	...	...	1	...	7	...	18	7	77	16
1871	23	12	18	5	4	...	...	...	1	...	12	3	20	10	78	30
1872	24	11	25	5	22	5	...	...	2	...	13	2	27	12	113	35
1873	23	8	22	10	15	...	...	...	2	...	16	...	14	1	92	19
1874	16	6	21	8	13	1	4	...	2	...	15	1	21	3	92	19
1875	28	15	23	15	17	3	2	...	1	...	13	1	15	5	99	39
1876	17	5	16	5	17	2	1	...	3	...	7	...	30	17	91	29
1877	27	11	17	2	13	4	1	...	1	...	7	1	14	...	80	18
1878	21	10	17	3	5	...	...	...	1	...	8	...	23	11	75	24
1879	26	10	25	7	15	...	...	...	2	...	12	1	12	3	92	21
1880	12	...	17	3	12	...	5	...	6	...	21	7	27	16	100	26
Range	29	22	28	17	22	5	5	...	6	...	21	7	30	17	113	35
	12	5	10	2	4	0	0	...	1	...	7	0	12	0	75	16
Means	22	9	20	6	14	2	1.4	...	2	...	12	1	21	8	92	26

Note.—"Some Frost" means any degree of frost, and includes whole frosty period, recorded by days. "All Frost" indicates days when temperature throughout is below 32°, or freezing.

IV.—THE ATLANTIC COAST BELT.

That part of the State which borders the ocean, and is near enough to be more directly exposed to the ameliorating influence of its waters, is here designated as the Atlantic Coast Belt. It is difficult to define its limits, as it merges into that of the Southern Interior on the west. The influence of the ocean's waters is felt very decidedly to a distance of four to eight miles from the line of beach or outer coast line, from Sandy Hook to Cape May. In Monmouth county it is thought to be four or five miles; in Ocean county it follows closely the line of clearings or settlements, not going beyond the line of woods or into the forest belt. It is here from four to seven miles wide. In Burlington, Atlantic and Cape May the breadth is five to eight miles. Open bays and tide marshes, as along the Little Egg Harbor river and Great Egg Harbor, allow the winds of the ocean and the tidal waters to carry these influences further inland. The western limit of the summer sea breezes is often further in the interior, particularly in very dry and hot seasons. It is noticed at least ten to twenty miles at such times, but these are exceptions. In severe storms the sea air is felt for several miles back from the shore, and the salt spray is carried in so as to affect vegetation throughout a narrow strip bordering the ocean and the salt water bays.* They are not generally felt in the pines a short distance back of the line of settlements. And so far as the effect of the ocean is more immediately felt, the western limit of the Atlantic coast belt may be said to run parallel to the beach and about five miles from it. As the distance from Sandy Hook to the peninsula, or more southern part of Cape May, is 100 miles, the area, including land and water surfaces, is about 500 square miles. Considering the ocean only, this belt should run to Cape May Point, but owing to the almost insular position of the southern part of Cape May county and its peculiar features of climate, this division is made to stop short of that part of the county, and the latter is constituted a separate climatic province. The stations of the U. S. Signal Service Bureau, at Sandy Hook, Barnegat, Atlantic City, together with the records kept for shorter periods at Middletown, Long Branch, Squan Beach and Peck's Beach, furnish reliable data for comparisons and for general description of the belt. The mean temperatures of months, seasons and year have been obtained by comparing the records for Sandy Hook, Barnegat and Atlantic City, with Newark, for a like period, and then reducing them to represent a term of 38 years in length. The means thus obtained for seasons and the year are as follows:

Spring	46.59°
Summer	68.80°
Autumn	55.43°
Winter	33.27°
Year	51.02°

*According to statement of Eli Collins, of Barnegat, a *dry storm*, September 3d, 1821, carried spray of salt water three miles inland, upsetting stacks, &c. It lasted from 9 A. M. to 3 P. M. For two hours it was cloudy and dark—a hurricane. It killed the leaves of the trees, and after they fell new buds and flowers were developed the same year. Trees were not, however, killed. [*From notes taken by Prof. Cook, in* 1856.]

The same gale was felt with great violence on the Long Island coast, and in a recent published account of it, Col. B. Ayerigg, of Passaic, who was staying at Jerusalem, on the south side, says: "Its violence may be estimated from the fact that where I was staying, at two miles from the bay and six miles from the sea, the salt water was blown against the windows and left a crust of salt, which had the effect of ground glass, and the leaves on the southeast sides of the trees were killed, turned brown and dropped off."

These figures show the milder winter, the warmer autumn and the cooler spring and summer than are observed in the same latitude in the Southern Interior division, or even the Red Sandstone plain. The diagram (Plate I.), exhibits these contrasts more clearly than the figures of the table. As compared with interior stations, the difference appears to reach the maximum in July. Plate III. shows the increments of heat at these stations as advancing until the maximum for the year is reached in August. The decline is then slower to the lowest mean temperature, in January. The three stations agree closely through the autumn and winter, but in May and in the summer months the average temperature of Sandy Hook runs from one to two and a half degrees higher than Barnegat or Atlantic City. It is noticeable that the average for the winter at these seaside localities is about 32°—that of the formation of ice. In the annual averages there is a difference of one degree between the coast and the Southern Interior stations. The curve of Plate I. expresses the equalizing influence of the water. The extremes of the year give a range of 110° in the whole belt, as against 121° in the Southern Interior. The lowest temperatures on record are 5° to 10° below zero, the highest 99° and 100° degrees above. The sea winds are warmer in winter and cooler in summer, than those blowing off shore. The sea breezes of the hot season spring up generally about noon, so that the maximum for the day is before noon, or at noon, just before the incoming of the cool sea air. The influence of these sea winds is to temper the extreme heat, to reduce both the range and the mean temperature in the warmer months, and to give a more humid character to the air. During the cold weather the storms which bring snow in the interior are accompanied by rain along the coast. The snow disappears more quickly at these localities. Sleighing is possible for very brief periods only. At Atlantic City it is unknown some winters. These sea beaches, situated as they are, with the ocean on one side and the tidal waters on the other, have a climate partaking slightly of the insular type. Barnegat station is separated from the main-land by the Barnegat bay, which is four miles wide. Atlantic City is at least five miles in a direct line from the nearest main-land. But the maximum and minimum temperatures at each of these stations, given in Table I., show that the range in the year is considerable, notwithstanding their situation. It is probable that the daily ranges are less and that the changes are not so sudden as inland. Plate II. exhibits the average highest daily and the average lowest daily temperatures by months, at these coast stations, together with those of Cape May, New York, Philadelphia and Baltimore. The stations are each represented by columns, with special designation—and the top of the same indicates the average maximum, the bottom the average minimum, and, hence, the length stands for the range. It shows at a glance the evenness of temperature at the seaside as compared with the other stations represented on this plate. The period covered by these averages is that of 1875–80, inclusive. That the seaside is more comfortable in the extreme hot weather of our summers is attested by the throngs of thousands of visitors who seek comfort and relief from the heat at the many localities, long and justly famous for their attractiveness. From Sandy Hook to Cape May the whole length of beach will probably be all taken up very soon for summer homes and seaside resorts. The new places which have sprung up since the Geological Survey's first maps appeared, form an almost continuous line from Sandy Hook to Point Pleasant. And the maps accompanying our annual reports indicate how rapid and extensive the changes are to suit the increasing patronage of our coast. The records of meteorological stations, like figures in so many places, cannot express all the peculiarities of climate, and they often fail to indicate the nicer and more delicate distinctions in the quality or tone of the atmosphere, which, especially at the seaside, impart to it its wondrous properties in building up the system. Thus, a high temperature, if not long continued, may not give great discomfort. The cool and pleasant afternoons and nights carry one over the heat of the forenoon. Again, the denser air, the presence of ozone, and the absence of impurities or poisonous exhalations, all tend to produce an effect which thermometers and rain gauges do not measure.

The influence of the water in lessening the severity of the winter has suggested this coast as a winter resort, and very much has been written about the mildness and dryness of the air at some localities. Atlantic City has become noted as such, and has been visited every winter for several years past by many persons, who find it more comfortable than Philadelphia or New York. Invalids are said to find its climate equally beneficial to them as that of more southern latitudes. Its southern front to the ocean may partly explain its attractiveness in the winter. The increasing westerly trend of the coast line from Barnegat Inlet southward, and again from Little Egg Harbor Inlet to Absecon Inlet, and from the latter to Peck's

Beach may be in some way connected with a nearer approach of a part of the Gulf Stream, or, as has been referred to on a preceding page of this report, to a reflux current from it, which flows southwesterly along the shore. The nearer approach of the Gulf Stream to our coast in winter has been said to make its winters milder, but this influence cannot be restricted to a single beach only. That the path of the Gulf Stream is nearer our coast in winter must have some effect upon our climate. And the delightfully warm weather when the wind comes in from a southeast quarter, is evidence of its existence not so far away from our shore. The general influence of the Gulf Stream as given by Chas. A. Schott, of the U. S. Coast Survey, in Smithsonian Contributions to Knowledge, No. 277, p. 105, may be thus summarized: "In the *winter* months the proximity of the Gulf Stream to the Atlantic sea-board has the effect of *elevating* the temperature in the vicinity of the ocean, the amount being 0° in Florida, about 4° in North Carolina, and about 8° or 10° in Massachusetts; in the summer months the effect is reversed as shown by the isotherals curving southward; this is due to the cold current running southward, between the coast and the Gulf Stream, and the depression produced would be still greater, but for the circumstances of the prevalence of the *westerly* winds, which carry the heated air to seaward. The depressing effect, however, in amount, is less than one-half that given for the opposite season."

From Point Pleasant, in Ocean county, to Cape May, there is a narrow strip of cultivated country which fronts on the bays and tide-waters, and is bounded by the forests on the west. It is equally exposed to the sweep of the sea winds, but it differs from the beaches in that the prevailing winds pass over forests and pine barrens, and not over waters or tide meadows. What may be the exact effect of the latter upon the temperature is yet undetermined, as there are no records from this narrow fringe of settlements to use in comparisons with other locations. But we should expect that there would be a slight difference in favor of the beaches in the greater equability of climate.

In conclusion, the climate of the shore belt is not marked by so sudden and severe changes as that of the interior. And the period between the frosts from spring to autumn, is doubtless longer. The cold waves do not strike it with so much severity.*

* During the cold wave of October 5th, 1881, there was no frost at Atlantic City to harm vegetation, while in the same parallels to the west, in the interior, it was severely felt.

The surface of this coast belt is a sandy loam on the main-land, and a clean sand on the beaches. The influence is at a minimum in the face of the ocean front. The elevations, also, are inconsiderable, nowhere exceeding 50 feet above tide level.

V.—DELAWARE BAY BELT.

A belt of the low-lying, alluvial necks and tidal meadows, bordering the Delaware bay and the lower part of the Delaware river, in Salem, Cumberland and Cape May counties, appears to be marked by peculiarities sufficient to make it a distinct climatic division of the State. Its length, from Gloucester county to Dennis creek, is about 40 miles, and its average breadth is 8 to 10 miles, making an area of nearly 400 square miles. Greenwich and Salem are on it, and Bridgeton is near its northern border. To the southeast its limit has been placed at or near Dennis creek, but it may extend somewhat further south, towards Cape May City. Up the Delaware it may stretch into Gloucester county, quite to Philadelphia. This belt is characterized by its tide-marsh area and banked meadows, and the low, fertile lands, known as *necks*. No part of it is elevated more than a few feet above tide level, and nearly all of it belongs to a recent geological period, and a very small part of it is in forest. Neither its elevation nor its surface can have much influence in the determination of climate. The chief factor is the nearness to the waters of the river and bay on the west and southwest. The river is from 1 to 5 miles and the bay from 15 to 25 miles wide. The only localities from which we have records are Greenwich, in Cumberland county, and Fort Delaware, in the river, nearly opposite the mouth of Salem creek. These stations indicate by their records the greater mildness of the winter, spring and autumn, as compared with stations further to the northeast. The results of the Greenwich observations, compared with and reduced to correspond with Newark, give the following mean temperatures for the year and by seasons:

Spring	50.97°
Summer	73.50°
Autumn	55.03°
Winter	34.03°
Year	53.38°

The graphic representation of Plate I. shows the annual curve of Greenwich to run higher in the summer than those of the other divisions, and in winter higher than all but Cape May. The winter is on the average 2.1° warmer, and the spring 1.14° warmer than the same seasons in the Southern Interior. In comparison with Atlantic City, which is on the same parallel of latitude, Greenwich for the year is 2° warmer; the winter temperatures practically agree, both being made more even by the presence of bodies of water near them, but the summer at Greenwich is 5° warmer than at the seaside. As already remarked, there is about a month's difference between this part of the State and the extreme north end in the spring, and nearly as much in the autumn, making the season nearly two months longer.* The winter is not only mild, but is not accompanied by much snow. The account given in DeVries' Journal in 1641, is true of some of the winters of the present time.

VI.—PENINSULA OF CAPE MAY.

The more southern part of Cape May county, embracing nearly all of the lower and middle townships, forms a peninsula, which is bounded on the east by the ocean, and on the west by Delaware bay. Both its more southern latitude and its proximity to the waters of the bay and ocean, tend to give it a warmer and more even climate than that of the other divisions of the State. Meteorological records have been kept at Seaville, Rio Grande, and Cape May City and Cape May Point. The records at the Cape have been compared with those of Newark and reduced. As compared with the Southern Interior, the winters at the Cape are, on the average, 4° warmer; the autumns are about 3° warmer, while the summers are 3° cooler. The greatest monthly differences are from October to March, when Cape May is 2° to 5° warmer. The diagram (Plate I.) gives more clearly the monthly variations, in comparison with the other provinces of the State. For purposes of more accurate comparison, and in order to show the prominent features of our sea-shore, the following table of the average highest and the average lowest daily temperatures, by months, at New York, Sandy Hook, Barnegat, Atlantic City, Cape May, Philadelphia and Baltimore, for the years 1875–1880, inclusive, is here presented.

*The spring at Greenwich is about two weeks earlier, as shown in blossoming of the peach, the cherry, and the apple, than it is at Perth Amboy, and 10 days in advance of Trenton.

TABLE

Showing the Average Highest Daily Temperatures, and Average Lowest Daily Temperatures, by Months—Period 1875–1880, Six Years.

	JAN.		FEB.		MARCH.		APRIL.		MAY.		JUNE.		JULY.		AUG.		SEPT.		OCT.		NOV.		DEC.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
New York City, N. Y.	38	23	40	24	45	31	56	40	69	52	77	61	82	67	80	65	73	58	63	47	49	37	39	26
Sandy Hook, N. J.	37	25	39	26	44	31	54	41	69	52	77	62	82	68	79	67	71	60	62	51	50	38	40	28
Barnegat, N. J.	39	24	39	25	44	31	54	39	65	50	73	58	79	64	79	65	71	59	64	48	49	36	40	27
Atlantic City, N. J.	40	25	40	25	46	31	54	39	65	50	74	59	79	65	79	66	72	59	63	48	50	36	41	27
Cape May, N. J.	41	29	41	30	47	35	54	43	66	53	74	63	79	69	79	69	72	63	65	52	52	41	43	32
Philadelphia, Pa.	40	25	41	26	48	32	59	42	70	53	79	63	84	69	81	67	73	57	65	48	50	38	40	27
Baltimore, Md.	42	28	43	30	51	34	61	44	73	55	82	65	86	71	82	67	75	59	65	49	52	38	43	29

TABLE

Showing the Extreme Temperatures, by Months—Period 1875–1880, Six Years.

	JAN.		FEB.		MARCH.		APRIL.		MAY.		JUNE.		JULY.		AUG.		SEPT.		OCT.		NOV.		DEC.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
New York City, N. Y.	64	-6	65	-1	72	8	81	21	94	34	95	47	99	59	90	55	94	42	88	31	73	7	62	-6
Sandy Hook, N. J.	61	-3	64	2	67	11	77	23	93	35	93	50	100	50	93	57	92	40	84	33	71	8	68	1
Barnegat, N. J.	61	-12	70	-1	73	10	79	19	91	34	93	47	96	53	93	55	90	41	82	28	73	11	63	-7
Atlantic City, N. J.	64	-3	71	-5	72	10	79	19	89	33	90	47	99	53	89	53	94	43	81	29	72	10	64	-7
Cape May, N. J.	58	1	59	2	69	13	76	24	81	37	89	47	90	56	88	57	87	42	81	33	72	14	61	2
Philadelphia, Pa.	67	-5	67	-1	75	9	81	20	96	35	95	49	100	60	93	55	91	43	87	31	77	8	65	-5
Baltimore, Md.	71	-1.5	67	-3	76	9	83	23.5	94	34	97	51	99	59	94	55	92	40	89	30	78	15	67	-3

PLATE II.

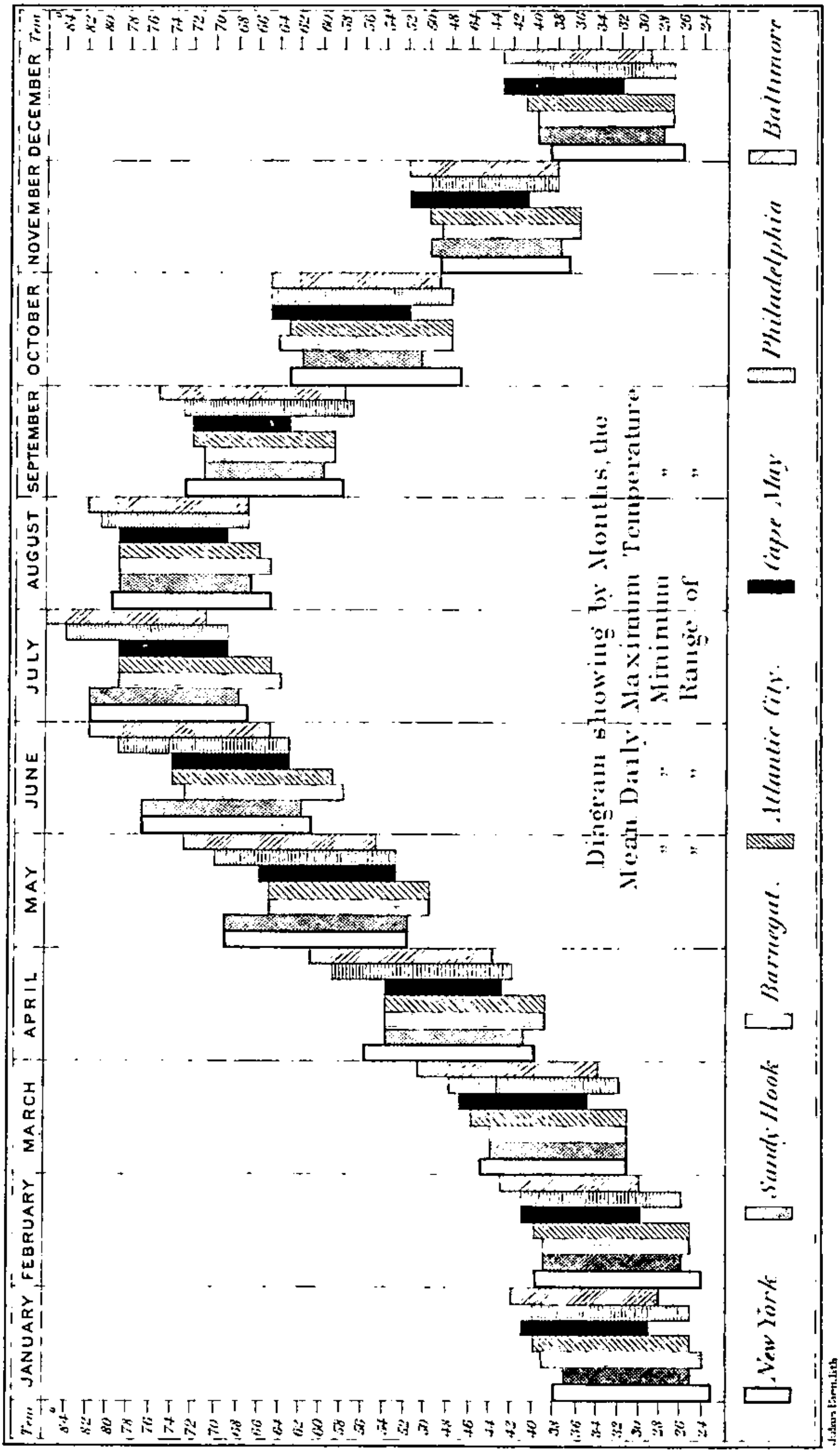


Diagram showing by Months, the Mean Daily Maximum Temperature
" " " Minimum "
" " " Range of "
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
Tem.
New York
Sandy Hook
Barnegat.
Atlantic City.
Cape May
Philadelphia
Baltimore

These figures give the *average* extremes for each month of the year; that is, they indicate the highest and lowest temperatures which we may expect every day in any given month. The second part of the table gives the recorded extremes. It shows us what temperatures may be possibly experienced at these several places in the several months; the upper one shows what are probable. The months stand at the head of the double columns. The first of each gives the average maximum, and the second the average minimum temperature. Since these observations were in each case taken by means of instruments of like pattern, and compared with standards, and were made under the general supervision of the U. S. Signal Service office, and cover the same period of six years, the results are valuable and suggestive. A longer period might change slightly some of the figures, but would not be likely to alter their relations nor affect any comparisons. It would be very desirable to have stations further in the interior, and especially in our Highlands. In the absence of such, the daily records made in New York, Philadelphia and Baltimore, are substituted. New York City may represent the northeast part of our Red Sandstone plain, and Philadelphia our Southern Interior.

The following diagram (Plate II.), drawn to a vertical scale, gives a graphic illustration, which is more easily studied than the table. The temperature is expressed in figures at the sides. The several months are in vertical columns. In each of these monthly columns the seven stations are represented by vertical bars, whose upper ends represent the average highest temperature for the month, and whose lower ends that of the average lowest temperature, and hence the length stands for the average range of temperature. The longer the bar, the greater the monthly range, and conversely. The figures at the sides enable us to carry the lines across so as to get the temperatures for each month at any of the stations. By means of this diagram we see, *first,* the greater equability of the seaside climate as compared with that of Philadelphia or Baltimore. The winters are warmer and the summers are cooler. *Second,* the greater mildness of the winter at Cape May is also apparent. The average maximum temperature for December is 3° above that of Philadelphia; that of January is one degree higher; February is the same. The average daily minimum differs still more, being 4° to 5° above that of Philadelphia, and 6° above that of New York, in the winter months. The average daily range in the winter at Cape May is 11° to 12°; that of Philadelphia 13° to 15°; that of New York City 13° to 16°. In the summer the contrast is nearly as marked. Then the average minimum does not differ from that of Philadelphia, while the average maximum is two to five degrees lower. The autumn shows like differences. The average lowest monthly temperature in August at Cape May is the same as that for July. The decline to September is 6°, whereas at Philadelphia the average minimum in September falls 12° below that of July and 10° below that of August. The heat lessens more gradually at the seaside. The large bodies of water tend to keep up the warmth in the autumn. The difference in the spring is less marked.

In the table of extremes we see more plainly the greater ranges of temperature inland as compared with Cape May and the other shore stations. Thus, at Cape May, the January range is 57°; that of Philadelphia 72°, and that of New York 70°. In July the figures are, Cape May 36°, and Philadelphia 40°.

There is a noteworthy difference in the winter season, between Cape May and the other coast stations. It is seen in the difference in the average daily minimum, which at Barnegat and Atlantic City, is four to five degrees lower than it is at Cape May. The extreme temperatures at these places also run lower—from four to nine degrees. The more southern situation of Cape May has something to do with this higher average minimum of the winter. But the Delaware bay on the west explains a part of it. The winter winds from west and west-northwest points of the compass are tempered by the latter, and are not so cold as land winds generally. The position of Cape May is more *insular* than that of Atlantic City or Barnegat. The evenness of its temperature is quite remarkable for its latitude, and for our Middle Atlantic coast. In its slight daily range it compares favorable with more southern stations in our country. It is warmer in winter than Washington, and its mean daily range of temperature is four degrees less than that of Norfolk, Va. The Monthly Weather Review of the U. S. Signal office, nearly every month gives Cape May as having the least daily range of temperature among its Middle States stations. And the range is nearly as low as that of Cape Lookout, in North Carolina, and Key West, New Orleans and Galveston, in the Gulf States. The average as there stated for three years past, is, for Cape May, 19°, while that of Key West is 16.° These figures show that in the *daily* range of temperature Cape May compares favorable with our most southern localities. Of course the *monthly* range exceeds that of the more southern stations here mentioned. The changes are not generally sudden.*

It is interesting here to observe that the isothermal line of 36°, the mean temperature, runs, according to the charts of the Smithsonian Institution, through West Virginia, North Carolina, Northern Georgia, Eastern Tennessee and Southern Missouri, near the parallels of 36° and 37° north latitude. The effect of so high a mean temperature in the spring is to produce crops of vegetables and small fruits quite as early as Portsmouth and Norfolk, Virginia. And the season is generally about a month in advance of it in the northern part of the State. But in late springs the difference is not quite so much. The summer is warm enough and the season long enough to produce cotton.† According to Blodgett's "Climatology of the United States," pp. 436–7, Huntsville, Alabama, represents one of the best cotton districts near the limit of its northern extension. Now, the mean temperature of Huntsville, in the winter, is, on the average, 7° higher than it is at Cape May, but the thermometer often falls to zero, and occasionally several degrees below zero,

*The equability of the climate of Cape May is more plainly shown by a comparison of the figures of Newark and those of the U. S. Signal Service Station at Cape May Point, during the months of October and November of the present (1881) year:

	OCTOBER.		NOVEMBER.	
	Newark.	Cape May.	Newark.	Cape May.
	Degrees.	Degrees.	Degrees.	Degrees.
Maximum temperature	83	81	68¾	67
Minimum temperature	33¾	39	22¼	27
Mean daily temperature	57.9	62.6	44.1	52.1
Range for month	49¼	42	46½	40
Greatest daily range	25	24	22	21
Least daily range	2	3	4	5
	Days.	Days.	Days.	Days.
Days on which *maximum* was 80° and upwards	2	4	......	*a*
" " " between 70° & 80°	8	6	......	......
" " " " 60° & 70°	12	18	2	12
" " " " 50° & 60°	8	3	13	13
" " " " 40° & 50°	1	......	12	3
" " " " 30° & 40°	......	......	3	......
Days whose *minimum* was between 20° & 30°	......	......	7	1*b*
" " " " 30° & 40°	7	2	11	8
" " " " 40° & 50°	9	7	7	12
" " " " 50° & 60°	7	11	5	5
" " " " 60° & 70°	8	8	......	2
" " " " 70° & 80°	......	3	......	......

a 25th and 26th wanting. *b* 26th and 27th wanting.

†Dr. John Wiley, of Cape May Court House, says, in a recent letter: "Your favor duly received, inquiring about the cultivation of cotton in Cape May. I know of no attempt to cultivate it here as a field crop. Persons occasionally plant a few seed out of curiosity. I have a sample of some which I raised in my garden in summer of 1880. Very little attention was paid to the plants, but in the fall they had quite a large number of bolls on them, containing prime cotton. I am well satisfied that with proper attention cotton could be successfully cultivated as a field crop in Cape May. We are exempt from frost usually one month longer than in the interior of the State, more especially in the lower part, where the ocean and Delaware bay both moderate the temperature."

extremes unknown in Cape May. The following popular description of the climate of Cape May, by Dr. S. S. Marçy, appeared in the "Geology of the County of Cape May," Trenton, 1857, p. 89:

"Our winters embrace every variety of cold and temperate weather. Ice is rarely obtained in this neighborhood more than four inches thick, and frequently but three inches; often it is but a short time that it can be obtained of this thickness. It is cut from still water, in artificial ponds, which are only one or two feet deep. So great is the uncertainty of obtaining a supply of ice, that we commence filling our ice-houses with ice from two and a half to three inches thick; and every team within a distance of six miles is put in requisition for that purpose, with *retaining fee,* some weeks before the appearance of the ice.

"The lowest temperature observed here for the last 30 years was 2° above zero. This was on the 9th of January, 1856. On the 10th it was 4°, and for several days the thermometer was as low as 8° or 10°. This will long be remembered as the cold winter of 1855–6. In our winters generally, the thermometer does not fall below 14° to 18°, though it has been known as low as 8° above. Up to last winter the latter was thought to be the extreme of cold weather here.*

"The mildness of our winters admits of large numbers of cattle being wintered on Seven, Five and Two-Mile beaches, without any provision being made for them by their owners. In cold weather they find shelter in the thickets on the beach."

Hon. Wm. B. Miller, Senator from Cape May county, in a recent letter, writes: "Snow does not lay over 12 hours when we have a deep fall. There are but few days in the winter that farmers in the vicinity cannot plow (last winter being an exception for many years)."

The milder climate of Cape May appears in the character of its flora. In reference to the existence of plants of a more southern range, Dr. N. L. Britton, of the Columbia College School of Mines, and author of "A Preliminary Catalogue of the Flora of New Jersey," gives the following points, viz.:

(1.) All the southern counties of New Jersey have a somewhat

*The cold wave of December, 1880, was remarkable throughout the country, and no part of New Jersey escaped its influence. The following extract from the *Monthly Weather Review* for December, 1880, shows its extent and enables us to make some comparison with the rest of the country: "The zero isotherm of minimum temperatures, quitting the New Jersey coast north of Cape May, ran southwestward through Eastern Virginia to the northeastern part of South Carolina, thence nearly due west to Fort Sill, in Indian Territory, and southwestward to the valley of the Rio Grande, in Texas; and following that valley up its full extent, reached the northern boundary of the United States, along the western edge of the Rocky mountain range." Temperatures of 1° to 4° above were reported from Middle and Northern Georgia, and 3° to 5° in Eastern Tennessee.

southern flora, and it seems true that the further south we go the more pronounced does this become.

(2.) "Although Cape May county has never been botanically explored to the extent that discoveries already made should warrant, yet it has already yielded a number of species of more southern distribution, and so far as known is the northern limit of the following six: Œnothera humifusa, Nutt; Galium hispidulum, Michx; Diodia Virginica, L.; Conoclinum cœlestinum, DC.; Pleuchea bifrons, DC.; Paspalum Walterianum, Schultes. These are all the southern species of the New Jersey flora at present known to occur only on Cape May, but I have no doubt that further exploration will add others to this list.

"Besides these species the following have been found on Cape May, but also in one or two other localities in the southern part of the State: Kosteletzkya Virginica, Presl; Lobelia puberula, Michx; Smilax Walteri, Pursh; Fuirena squarrosa, Michx; Panicum viscidum, Ell.

(3.) "In addition to the above lists it may be stated that there are other species of a southern character, which probably occur in greater abundance in Cape May county than in any other part of New Jersey."

The Euonymus Japonica, commonly known as the *Chinese Box*, is cultivated in gardens and door-yards at Cape May City as an ornamental shrub, and appears to thrive out of doors, although it is not hardy north. In the Southern States it is common.

EXPLANATION OF TABLES OF TEMPERATURE.

The tables of temperature have been modeled after those of Chas. A. Schott (of U. S. Coast Survey), as published in "Smithsonian Contributions to Knowledge," No. 277. They contain the name of station, geographical position, elevation, mean, maximum and minimum temperatures by months, mean temperatures by seasons, and for the year and length of period of observation.

The arrangement of the localities, or meteorological stations, is geographical, beginning with those furthest north and going southward. And they appear in groups, corresponding in general to the divisions of the State, designated as climatological provinces. In the table, the three stations properly belonging to the Red Sandstone, viz., New York City, Fort Columbus and Jersey City, appear as one group. The remaining stations of the same province are placed in two groups, the one representing the northeastern and central parts; the other, the extreme western part. The division or province designated as the Southern Interior, also covers three groups: the first, with Freehold and Hightstown; the second, containing the central portion of the division; and the third, the stations along the Delaware river.

The geographical positions are given to the nearest minute of latitude and longitude. The longitude is that west of Greenwich.

The elevations are expressed in feet above mean tide level, so far as they could be ascertained from railroad surveys, and from the topographical maps of the Geological Survey. Wherever such data were not to be had, the heights, as estimated, are given in brackets. They are believed to be very close approximations to the correct figures.

The "Tables of Atmospheric Temperature" in "Smithsonian Contributions to Knowledge," furnish heights for several stations.

The temperature is given in columns arranged by months, by the year and by seasons. In the monthly columns, the first of each gives the maximum or highest temperature *observed for that month* during the period covered by the record. The second column gives the minimum or lowest observed temperature for the month. And the third gives the mean daily temperature. The range for any given month is, therefore, apparent in the difference between the maximum and the minimum temperatures, as shown in the first and second columns. The mean annual temperature is the mean obtained from the several mean monthly temperatures. Following this column for the mean, are three columns giving the maximum, the minimum and the range of temperature for the year. Then follow the mean temperatures for the four seasons, consisting of the calendar months as commonly placed in them. In the three columns headed series, the dates of commencement, of end and the length of the observing period are given. The length in most cases consists of the actual time covered by the record, and it is not always the same as that comprised between the dates of beginning and end. The names of observers, so far as obtainable, are given in the last column.

The authorities for the tables are Schott's "Tables of Atmospheric Temperature," in "Smithsonian Contributions to Knowledge," No. 277; copies of records furnished by the Smithsonian Institution; copies of the records of the U. S. Signal Service Stations, contributed by the Chief Signal Officer of the U. S. Army; "Army Meteorological Register," Washington, 1851 and 1856; the annual

TABLE OF TEMPERATURE.

No.	STATIONS.	Latitude.	Longitude.	Height—feet.	January. Maximum.	January. Minimum.	January. Mean.	February. Maximum.	February. Minimum.	February. Mean.	March. Maximum.	March. Minimum.	March. Mean.	April. Maximum.	April. Minimum.	April. Mean.
1	White Plains, Westchester Co., N. Y.	41° 02′	73° 46′	200	66.0	-20.0	29.94	68.0	-2.0	30.69	70.0	2.0	35.14	84.0	15.0	47.95
2	West Point, Orange Co., N. Y.	41° 24′	73° 57′	167	68.0	-30.0	28.68	67.0	-10.0	29.60	82.0	-6.0	37.85	89.0	14.0	49.27
3	Goshen, Orange Co., N. Y.	41° 23′	74° 20′	425	60.0	-30.0	25.65	60.0	-16.0	26.31	78.0	-5.0	36.54	84.0	10.0	47.41
4	Port Jervis, Orange Co., N. Y.	41° 22′	74° 42′	450	56.0	0.0	31.40	61.0	-7.0	29.80	64.0	11.0	32.30	84.0	26.0	47.30
5	Deckertown, Sussex Co.	41° 12′	74° 36′	470	54.0	-2.0	32.90	64.0	-7.0	31.20	64.0	14.0	34.70	73.0	24.0	46.00
6	Newton, Sussex Co.	41° 04′	74° 45′	659	51.0	2.0	28.71	52.0	7.0	28.71	60.0	3.0	30.83	78.0	29.0	47.34
7	Dodge Mine, Morris Co.	41° 01′	74° 35′	1100	35.0	-6.0	19.10	65.0	-9.0	26.73	65.0	10.0	31.18	87.0	24.0	47.00
8	Mount Olive, Morris Co.	40° 48′	74° 49′	1206	......	......	......	......	......	......	......	......	......	......	......	......
9	Dover, Morris Co.	40° 54′	74° 34′	575	58.0	-5.0	26.99	59.0	-7.0	28.31	68.0	1.0	35.59	75.0	25.0	46.59
10	Easton, Northampton Co., Pa.	40° 43′	75° 16′	340	56.0	-14.5	24.29	66.0	-13.0	27.13	68.0	0.0	35.81	86.0	19.0	47.56
11	New York City, N. Y.	40° 42′	74° 00′	164	64.0	-13.0	30.21	65.0	-8.0	31.45	74.0	3.0	37.54	84.0	20.0	48.43
12	Fort Columbus, N. Y. Harbor, N. Y.	40° 42′	74° 01′	23	60.0	-12.0	29.87	68.0	-7.0	30.53	78.0	2.0	37.96	84.0	17.0	48.47
13	Jersey City, Hudson Co.	40° 43′	74° 03′	20	68.6	-5.7	31.51	74.6	-3.0	31.70	73.0	0.0	37.80	89.3	23.7	48.90
14	Paterson, Passaic Co.	40° 56′	74° 10′	60	62.0	-14.0	27.76	63.0	-6.0	29.86	72.0	1.0	36.15	87.0	22.0	49.49
15	Bloomfield, Essex Co.	40° 48′	74° 12′	120	57.0	-16.0	28.58	69.0	-9.0	30.58	74.0	2.0	36.01	84.5	16.0	47.36
16	Newark, Essex Co.	40° 44′	74° 10′	35	65.0	-12.7	28.51	68.5	-8.0	29.87	77.2	2.0	37.39	85.5	17.0	48.31
17	East Orange, Essex Co.	40° 46′	74° 12′	160	53.0	-4.3	......	49.4	9.0	......	65.2	8.1	......	76.1	23.6	......
18	Orange, Essex Co.	40° 47′	74° 13′	185	53.0	-2.0	29.78	59.0	-0.5	30.75	70.0	3.0	33.91	90.0	35.0	47.32
19	South Orange, Essex Co.	40° 45′	74° 15′	140	70.0	-22.0	29.24	74.0	-3.0	29.61	72.0	-0.5	36.58	88.0	24.0	47.96
20	Linden, Union Co.	40° 37′	74° 15′	25	63.5	-7.0	28.46	65.0	-2.5	30.90	72.0	15.0	37.76	83.0	25.4	48.45
21	Passaic Valley, Union Co.	40° 41′	74° 27′	210	......	......	......	......	......	......	......	......	......	......	......	......
22	New Germantown, Hunterdon Co.	40° 41′	74° 45′	320	64.5	-14.5	28.50	71.0	-4.5	27.63	66.5	-1.0	33.70	83.0	23.0	47.01
23	Pleasant Run, Hunterdon Co.	40° 33′	74° 47′	[330]	......	......	......	......	......	......	68.0	18.0	......	74.0	40.0	......
24	Readington, Hunterdon Co.	40° 34′	74° 43′	[90]	55.0	-3.0	25.98	50.0	-6.0	30.23	58.0	5.0	33.46	84.0	29.0	51.12
25	White House, Hunterdon Co.	40° 37′	74° 45′	180	......	......	......	......	......	......	......	......	......	......	......	......
26	Sergeantville, Hunterdon Co.	40° 27′	74° 57′	[250]	68.0	-12.0	28.54	67.0	-3.0	31.39	81.0	6.0	38.65	71.0	10.0	43.02
27	Lesser Cross Roads, Somerset Co.	40° 41′	74° 38′	184	58.0	14.0	36.13	56.0	9.0	31.73	......	......	......	......	......	......
28	Ringoes, Hunterdon Co.	40° 25′	74° 52′	248	70.0	16.0	......	60.0	6.0	......	......	......	......	......	......	......
29	Somerville, Somerset Co.	40° 34′	74° 36′	65	61.0	-11.0	28.75	61.5	5.0	28.70	69.0	17.0	35.70	81.0	23.0	45.82
30	Roycefield, Somerset Co.	40° 32′	74° 34′	110	50.0	-22.0	27.02	60.0	-2.0	29.57	......	......	......	82.0	34.0	51.80
31	New Brunswick, Middlesex Co.	40° 29′	74° 27′	90	67.0	-12.0	28.33	67.0	-10.0	30.63	77.0	4.0	36.21	81.0	27.0	49.37
32	Princeton, Mercer Co.	40° 21′	74° 39′	220	60.0	-8.0	28.45	67.0	1.0	29.75	71.0	13.0	36.00	81.0	19.0	47.15
33	Pennington, Mercer Co.	40° 19′	74° 46′	180	......	......	......	54.0	18.0	......	60.0	14.0	......	......	......	......
34	Lambertville, Hunterdon Co.	40° 23′	74° 57′	96	61.0	-20.0	29.72	67.4	-8.7	29.62	77.0	-0.7	38.27	85.0	14.1	48.35
35	Trenton, Mercer Co.	40° 14′	74° 45′	60	68.0	-13.0	31.10	68.0	-7.0	32.33	76.0	1.0	39.66	85.0	27.0	52.16
36	Morrisville, Bucks Co., Pa.	40° 13′	74° 52′	30	......	......	30.08	......	......	29.41	......	......	38.23	......	......	50.63
37	Fallsington, Bucks Co., Pa.	40° 12′	74° 48′	30	65.0	-9.0	30.14	68.0	-6.0	32.15	78.0	0.0	38.28	81.0	25.0	49.56
38	Sandy Hook, Monmouth Co.	40° 28′	74° 01′	30	63.0	-3.0	32.17	74.0	2.0	32.10	67.0	11.0	37.64	77.0	23.0	45.99
39	Riceville, Monmouth Co.	40° 24′	74° 02′	[200]	51.0	1.0	29.77	66.0	-5.0	36.80	75.0	14.0	38.67	88.0	33.0	48.68
40	Middletown, Monmouth Co.	40° 24′	74° 07′	50	......	......	34.80	......	......	35.48	......	......	41.81	......	......	53.10
41	Long Branch, Monmouth Co.	40° 18′	73° 59′	28	68.0	-5.0	34.23	73.0	1.0	31.60	69.0	12.0	36.90	67.0	20.0	42.80
42	Ocean Grove, Monmouth Co.	40° 12′	74° 00′	20	......	......	......	54.0	10.0	......	54.0	12.0	......	......	......	......
43	Squan Beach, Ocean Co.	40° 08′	74° 01′	23	70.0	-10.0	31.80	57.0	-5.0	27.50	67.0	9.0	35.00	67.0	15.0	40.60
44	Barnegat, Ocean Co.	39° 48′	74° 09′	20	61.0	-12.0	32.70	70.0	-1.0	32.70	73.0	10.0	38.19	79.0	19.0	45.67
45	Atlantic City, Atlantic Co.	39° 22′	74° 25′	14	64.0	-3.0	33.49	71.0	-5.0	33.57	72.0	10.0	38.63	79.0	19.0	46.40
46	Somers Point, Atlantic Co.	39° 19′	74° 37′	20	......	......	......	......	......	......	......	......	......	......	......	......
47	Peck's Beach, Cape May Co.	39° 11′	74° 41′	20	63.0	-3.0	34.10	61.0	0.0	31.30	65.0	12.0	37.00	66.0	20.0	42.80
48	Seaville, Cape May Co.	39° 11′	74° 45′	18	......	......	26.26	......	......	37.35	......	......	40.17	......	......	51.16
49	Freehold, Monmouth Co.	40° 15′	74° 16′	190	68.0	-8.0	31.09	69.0	-5.0	31.10	76.0	7.0	38.00	86.0	17.0	46.60
50	Hightstown, Mercer Co.	40° 16′	74° 32′	100	66.0	15.0	39.80	64.0	7.0	36.80	67.0	11.0	39.10	75.0	30.0	49.80
51	New Lisbon, Burlington Co.	39° 57′	74° 36′	52	62.0	6.0	......	77.0	11.0	......	74.0	20.0	......	84.0	22.0	......
52	Mount Holly, Burlington Co.	39° 59′	74° 48′	30	59.0	-9.0	29.60	65.0	-2.0	33.51	76.0	2.0	39.67	84.0	31.0	50.98
53	Moorestown, Burlington Co.	39° 58′	74° 57′	104	69.0	-13.0	29.72	72.0	-5.0	31.44	79.0	2.0	38.38	86.0	26.0	49.91
54	Haddonfield, Camden Co.	39° 53′	75° 02′	50	67.0	-12.0	29.61	61.0	-3.0	31.94	78.0	4.0	38.31	84.0	22.0	50.54
55	Atco, Camden Co.	39° 46′	74° 54′	150	70.0	-8.0	32.29	69.0	-2.0	32.36	74.0	3.0	38.52	92.0	22.0	49.18
56	Elwood, Atlantic Co.	39° 34′	74° 42′	[50]	......	......	......	......	......	......	75.0	4.0	39.80	71.0	19.0	46.40
57	Newfield, Gloucester Co.	39° 40′	74° 50′	125	68.0	1.0	35.18	68.0	-7.0	31.49	80.0	4.0	36.97	86.0	22.0	48.78
58	Vineland, Cumberland Co.	39° 29′	75° 01′	119	69.0	-10.0	31.98	75.0	-6.0	33.54	81.0	2.0	39.32	90.0	22.0	50.71
59	Florence, Burlington Co.	40° 07′	74° 49′	80	66.0	15.0	38.30	......	......	......	......	......	......	......	......	......
60	Burlington, Burlington Co.	40° 04′	74° 51′	60	......	......	28.87	......	......	31.39	......	......	39.10	......	......	49.85
61	Camden, Camden Co.	39° 57′	75° 08′	20	......	......	......	......	......	......	72.0	17.0	......	88.0	28.0	......
62	Philadelphia, Philadelphia Co., Pa.	39° 56′	75° 10′	36	67.0	-9.0	31.50	75.0	-2.0	32.72	79.0	5.0	40.10	88.0	17.5	50.43
63	Woodstown, Salem Co.	39° 39′	75° 19′	30	......	......	......	......	......	......	......	......	......	......	......	......
64	Salem, Salem Co.	39° 35′	75° 28′	15	55.0	-4.0	29.55	62.0	16.0	35.00	......	......	......	80.0	31.0	52.00
65	Allowaystown, Salem Co.	39° 34′	75° 22′	[15]	62.0	-6.0	28.99	60.0	0.0	29.94	64.0	3.0	33.28	87.0	32.0	48.55
66	Fort Delaware, Del.	39° 35′	75° 34′	10	62.0	-5.0	32.26	65.0	0.0	33.80	80.0	5.0	40.08	85.0	24.0	51.59
67	Greenwich, Cumberland Co.	39° 24′	75° 20′	30	62.0	-9.0	31.14	67.0	2.0	33.64	76.0	7.0	39.89	82.0	25.0	52.11
68	Dover, Kent Co., Del.	39° 10′	75° 30′	40	67.0	0.0	34.27	70.0	-3.0	36.79	74.0	8.0	42.12	88.0	28.0	52.62
69	Rio Grande, Cape May Co.	39° 01′	74° 53′	13	......	......	33.39	......	......	33.78	......	......	37.25	......	......	48.91
70	Cape May, Cape May Co.	38° 56′	74° 58′	28	......	......	34.88	......	......	34.51	......	......	39.69	......	......	47.67
71	Baltimore, Baltimore Co., Md.	39° 17′	76° 37′	80	69.0	-15.0	33.33	78.0	-4.0	34.86	76.0	0.0	42.06	89.0	20.0	52.84

No.	May. Maximum.	May. Minimum.	May. Mean.	June. Maximum.	June. Minimum.	June. Mean.	July. Maximum.	July. Minimum.	July. Mean.	August. Maximum.	August. Minimum.	August. Mean.	September. Maximum.	September. Minimum.	September. Mean.
1	89.0	29.0	58.82	93.0	48.0	68.37	92.00	55.0	73.14	89.0	44.00	69.38	85.00	35.0	63.03
2	93.0	27.0	60.68	99.0	40.0	69.64	101.00	51.0	74.51	101.0	46.00	72.57	99.00	36.0	65.10
3	89.0	26.0	56.22	96.0	36.0	64.73	96.00	42.0	68.69	91.0	36.00	67.64	88.00	32.0	59.76
4	95.0	34.0	65.30	91.0	50.0	68.30	91.00	56.0	70.80	90.0	46.00	68.30	87.00	40.0	61.40
5	98.0	35.0	60.50	......	......	......	......	......	......	100.0	46.00	74.60	89.00	40.0	64.40
6	83.0	36.0	55.96	84.0	48.0	64.78	92.00	57.0	69.40	......	......	......	......	......	......
7	96.0	36.5	64.60	94.0	46.5	67.26	90.00	50.0	68.93	91.0	48.00	66.74	87.00	40.0	59.98
8	......	......	......	......	......	......	87.00	57.0	......	86.0	51.00	67.48	84.00	......	......
9	80.0	37.0	54.92	88.0	51.0	66.65	98.00	56.0	72.70	88.0	53.00	69.94	84.00	41.0	62.57
10	94.0	38.0	58.69	102.0	42.0	69.33	102.00	52.0	74.43	101.0	48.00	69.64	94.00	36.0	63.56
11	94.0	34.0	59.04	97.0	46.0	69.62	99.00	56.0	74.72	96.0	53.00	73.11	94.00	40.0	65.42
12	92.0	31.0	59.43	98.0	42.0	69.46	104.00	54.0	75.09	99.0	49.00	73.38	92.00	39.0	65.96
13	93.4	35.5	62.30	96.2	48.5	72.90	99.50	52.0	77.50	93.6	53.20	74.40	92.80	35.7	67.20
14	95.0	30.0	60.82	97.0	48.0	70.74	98.00	61.0	75.15	93.0	52.00	71.35	93.00	42.0	64.95
15	94.0	34.0	57.60	99.0	48.0	69.16	102.00	53.0	73.99	99.0	45.50	71.01	95.00	36.0	64.60
16	96.0	31.0	59.19	97.0	38.2	68.60	99.75	46.2	73.96	99.0	46.75	71.25	93.75	34.5	63.61
17	83.9	33.4	......	94.9	43.7	69.70	99.00	53.0	76.75	93.5	51.10	75.07	89.70	35.4	64.00
18	98.0	38.0	62.65	99.0	55.0	73.42	98.00	63.0	75.93	94.0	58.00	74.35	93.00	39.0	67.17
19	95.0	36.0	61.12	100.0	48.0	70.23	101.00	55.0	73.88	98.0	50.00	71.43	94.00	33.0	62.37
20	97.0	37.5	60.88	99.2	47.5	68.57	100.00	55.0	73.47	93.2	53.20	70.31	92.90	37.6	63.18
21	......	......	......	98.0	48.0	68.00	......	......	......	......	......	......	......	......	......
22	92.0	37.5	59.73	97.0	36.5	70.11	97.30	58.2	74.06	96.0	51.00	71.26	90.20	38.0	62.56
23	84.0	40.0	......	......	......	......	......	......	......	......	......	......	94.00	48.0	67.70
24	90.0	30.0	62.37	94.0	46.0	70.87	96.00	54.0	74.46	94.0	53.00	73.39	92.00	36.0	62.75
25	81.0	44.0	62.00	87.0	50.0	71.80	......	......	......	......	......	......	......	......	......
26	87.0	35.0	60.42	93.0	55.0	69.61	97.00	55.0	74.86	96.0	61.00	76.45	87.00	46.0	71.17
27	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
28	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
29	94.0	30.5	62.83	94.0	51.0	68.90	95.00	53.0	72.50	90.5	49.00	67.20	91.00	35.0	63.00
30	95.0	44.0	63.08	92.0	54.0	71.12	......	......	......	......	......	......	90.00	50.0	66.52
31	98.0	37.0	59.39	98.0	46.0	68.83	101.00	56.0	74.73	97.0	48.00	71.85	92.00	42.0	63.82
32	97.0	27.0	63.45	97.0	48.0	71.80	93.00	55.0	72.80	89.0	51.00	70.70	91.00	35.0	66.05
33	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
34	93.5	29.0	59.16	100.0	38.0	68.37	101.50	44.0	73.52	97.5	40.00	70.78	97.00	32.5	62.93
35	94.0	31.0	61.67	95.0	39.0	71.92	99.00	55.0	75.97	96.0	53.00	74.01	92.00	39.0	66.64
36	......	......	62.80	......	......	71.45	......	......	75.36	......	......	72.30	......	......	65.57
37	87.0	37.0	59.60	95.0	50.0	69.20	98.00	55.0	73.65	99.0	55.00	72.28	88.00	43.0	65.20
38	93.0	35.0	59.14	97.0	49.0	68.67	100.00	50.0	74.26	93.0	55.00	72.47	92.00	40.0	66.01
39	74.0	36.0	55.55	88.0	51.0	68.00	93.00	53.0	71.24	97.0	58.00	67.70	......	......	......
40	......	......	61.47	......	......	66.83	......	......	71.93	......	......	72.23	......	......	66.40
41	87.0	35.0	56.30	94.0	49.0	67.56	94.00	57.0	72.10	92.0	56.00	70.55	88.50	45.0	65.80
42	86.0	43.0	......	92.0	56.0	......	93.00	60.0	......	86.0	62.00	72.70	96.00	49.0	......
43	88.0	30.0	54.40	95.0	40.0	65.80	91.00	52.0	70.30	94.0	48.00	69.80	90.00	35.0	64.70
44	91.0	34.0	57.28	94.0	47.0	66.32	96.00	53.0	71.78	95.0	53.00	71.41	90.00	41.0	65.67
45	89.0	33.0	57.46	93.0	45.0	66.69	99.00	53.0	71.73	89.0	53.00	71.97	94.00	43.5	66.35
46	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
47	86.0	33.0	55.60	90.0	48.0	65.00	94.00	56.0	71.90	87.0	50.00	70.50	88.00	38.0	65.70
48	......	......	53.38	......	......	70.98	......	......	76.72	......	......	74.48	......	......	69.69
49	94.0	32.0	59.46	96.0	40.5	69.29	99.00	50.0	73.81	95.0	46.50	71.58	91.00	37.0	63.97
50	87.0	36.0	59.40	......	......	......	......	......	......	......	......	......	......	......	......
51	101.0	40.0	......	100.0	50.0	73.50	......	......	......	......	......	......	......	......	......
52	85.0	34.0	60.35	95.0	50.0	69.03	98.00	56.0	73.03	92.0	51.00	71.65	86.00	45.0	65.31
53	97.0	36.0	60.85	99.0	48.0	70.91	102.00	58.0	75.68	98.0	54.00	73.06	92.00	37.0	65.06
54	85.0	37.0	59.41	96.0	50.0	70.06	102.00	58.0	74.66	97.0	51.00	72.19	90.00	45.0	65.47
55	97.0	32.0	62.43	99.0	50.0	71.88	101.00	59.0	75.49	98.0	46.00	73.12	92.00	36.0	64.94
56	80.0	......	56.23	94.0	......	67.90	96.00	62.0	76.85	90.0	55.00	72.48	90.00	39.0	65.88
57	92.0	43.0	59.73	100.0	51.0	72.83	101.00	58.0	77.45	101.0	55.00	73.43	95.00	40.0	65.87
58	96.0	34.0	62.03	100.0	44.0	73.21	106.00	46.0	77.90	102.0	49.00	74.17	96.00	37.0	66.21
59	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
60	......	......	60.17	......	......	70.09	......	......	74.57	......	......	71.36	......	......	65.54
61	93.0	40.0	......	......	......	......	......	......	......	......	......	......	......	......	......
62	96.0	31.0	61.43	98.0	42.0	71.21	101.00	50.0	76.11	97.0	50.00	73.51	93.00	37.0	65.70
63	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
64	96.0	39.0	61.00	95.0	57.0	73.00	101.00	65.0	77.00	......	......	74.00	......	......	......
65	94.0	40.0	60.64	95.0	52.0	70.36	103.00	65.0	78.46	94.0	57.00	73.60	98.00	45.0	66.51
66	91.0	38.0	63.44	97.0	49.0	72.25	101.00	53.0	77.61	101.0	51.00	75.84	90.00	47.0	69.60
67	87.0	40.0	61.01	94.0	50.0	71.17	95.00	55.0	76.09	93.0	53.00	73.69	89.00	42.0	66.28
68	92.0	40.0	63.65	96.0	56.0	73.45	99.00	60.0	77.87	99.0	60.00	75.45	96.00	42.0	67.09
69	......	......	58.38	......	......	72.33	......	......	74.70	......	......	73.76	......	......	66.38
70	......	......	58.00	......	......	68.09	......	......	74.10	......	......	73.11	......	......	67.13
71	94.0	31.0	63.26	100.0	45.0	72.23	100.00	54.0	77.14	100.0	50.00	75.12	94.00	38.0	68.05

No.	October. Maximum.	October. Minimum.	October. Mean.	November. Maximum.	November. Minimum.	November. Mean.	December. Maximum.	December. Minimum.	December. Mean.	Year. Mean Annual Temperature.	Year. Maximum.	Year. Minimum.	Year. Range for Year.	Mean Temperature. Spring.	Mean Temperature. Summer.	Mean Temperature. Autumn.	Mean Temperature. Winter.	Series. Beginning.	Series. End.	Length. Yrs.	Length. Mos.	OBSERVERS.	STATIONS.	No.
1	79.0	23.00	53.14	73.0	8.0	41.53	66.0	-14.0	30.72	50.15	91.00	-14.00	105.0	47.30	70.29	52.56	30.45	Jan., 1863	Dec., 1880	15	6	Prof. O. R. Willis	White Plains, Westchester Co., N. Y.	1
2	87.0	24.00	54.26	73.0	6.0	42.96	70.0	-11.0	32.49	51.47	101.00	-30.00	131.0	49.27	72.24	54.11	30.26	Jan., 1824	Dec., 1870	46	5	Assistant Surgeon, U. S. Army	West Point, Orange Co., N. Y.	2
3	82.0	14.00	48.87	78.0	4.0	38.78	62.0	-10.0	28.01	47.38	96.00	-30.00	126.0	46.72	67.02	49.13	26.66	Jan., 1835	Dec., 1849	11	...	Various Observers, N. Y. University System	Goshen, Orange Co., N. Y.	3
4	74.0	26.00	46.40	62.0	5.0	33.30	40.0	-14.0	22.70	48.11	95.00	-14.00	109.0	48.30	69.10	47.00	27.90	Jan., 1880	Dec., 1880	1	...	Charles F. Van Inwegen	Port Jervis, Orange Co., N. Y.	4
5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Jan., 1880	Sept., 1880	...	7	A. C. Noble	Deckertown, Sussex Co.	5
6	......	......	......	......	......	......	46.0	6.0	23.90	......	......	......	......	44.71	......	......	27.11	Dec., 1868	July, 1869	...	8	Dr. Thomas Ryerson	Newton, Sussex Co.	6
7	78.0	30.00	48.56	67.0	7.0	32.37	42.0	-11.0	22.08	46.21	94.00	-11.00	105.0	47.59	67.64	46.97	22.64	Jan., 1880	Feb., 1881	1	2	William Allen Smith	Dodge Mine, Morris Co.	7
8	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Aug., 1879	Aug., 1880	...	4	A. A. Titsworth	Mount Olive, Morris Co.	8
9	78.0	29.00	52.62	71.0	19.0	43.77	58.0	1.0	29.65	49.19	98.00	-7.00	105.0	45.70	69.76	52.99	28.32	Oct., 1866	Jan., 1869	2	4	H. Shriver	Dover, Morris Co.	9
10	87.0	26.00	50.72	72.0	9.0	40.36	64.0	-1.0	30.37	49.32	102.00	-14.50	116.5	47.35	71.13	51.55	27.26	Jan., 1855	Dec., 1859	5	...	S. J. Coffin, G. R. Houghton	Easton, Northampton Co., Pa.	10
11	88.0	31.00	54.21	73.0	7.0	44.88	69.0	-6.0	33.00	51.80	99.00	-13.00	112.0	48.34	72.48	54.83	31.55	Jan., 1844	Dec., 1880	31	11	Smithsonian Contributions to Knowledge, U. S. Signal Service Station	New York City, N. Y.	11
12	86.0	29.00	54.57	71.0	12.0	43.64	69.0	-3.0	33.50	51.82	104.00	-12.00	116.0	48.62	72.64	54.72	31.30	Oct., 1821	Dec., 1870	48	8	Assistant Surgeon, U. S. Army	Fort Columbus, N. Y. Harbor, N. Y.	12
13	84.0	30.00	55.30	74.0	7.3	42.40	67.7	-3.0	32.40	52.86	99.50	-5.70	105.2	49.66	74.93	54.96	31.86	Jan., 1871	Dec., 1878	6	7	T. T. Howard, Jr. and F. S. Cook	Jersey City, Hudson Co.	13
14	81.0	26.00	52.58	70.0	9.0	42.23	60.0	6.0	30.65	50.98	99.00	-14.00	113.0	48.82	72.41	53.25	29.42	Oct., 1863	Dec., 1880	8	9	W. Brooks, John T. Hilton	Paterson, Passaic Co.	14
15	90.0	28.00	54.19	75.0	15.0	43.65	66.0	1.0	33.67	50.87	102.00	-16.00	118.0	46.99	71.39	54.15	30.94	March, 1849	Dec., 1862	10	7	R. L. Cooke and A. Merrick	Bloomfield, Essex Co.	15
16	83.0	22.25	52.39	73.7	8.0	41.78	68.5	-7.5	31.38	50.52	99.75	-12.75	112.5	48.30	71.27	52.59	29.92	May, 1843	Dec., 1880	37	8	William A. Whitehead	Newark, Essex Co.	16
17	79.8	31.70	53.20	68.4	23.6	43.50	62.0	11.3	......	......	99.00	-4.00	103.0	......	73.84	53.50	......	June, 1877	Sept., 1879	2	1	Thomas T. Howard, Jr	East Orange, Essex Co.	17
18	84.0	30.00	53.92	66.0	17.0	38.41	64.0	3.0	31.32	51.57	99.00	-2.00	101.0	47.96	74.56	53.16	30.62	Jan., 1872	Dec., 1874	2	9	Dr. W. H. Stackwell	Orange, Essex Co.	18
19	87.0	22.00	52.74	76.0	8.0	39.74	70.0	-8.0	30.68	50.46	101.00	-22.00	123.0	48.55	71.85	51.62	29.84	Sept., 1870	Dec., 1880	10	3	Dr. William J. Chandler	South Orange, Essex Co.	19
20	85.5	23.00	52.79	84.0	9.5	40.76	59.0	-17.0	30.43	50.50	100.00	-17.00	117.0	49.03	70.78	52.24	29.93	Nov., 1876	Dec., 1880	4	2	Arthur B. Noll	Linden, Union Co.	20
21	72.0	24.00	51.90	......	......	......	55.0	2.0	29.00	......	......	......	......	......	......	......	......	Oct., 1863	June, 1864	...	3	W. Brooks	Passaic Valley, Union Co.	21
22	77.0	22.00	50.71	70.0	6.0	37.23	64.0	-6.5	29.02	49.28	97.30	-14.50	111.8	46.81	71.81	50.17	28.38	Nov., 1868	Aug., 1876	7	10	Arthur B. Noll	New Germantown, Hunterdon Co.	22
23	90.0	34.00	58.80	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Sept., 1877	May, 1878	...	5	......	Pleasant Run, Hunterdon Co.	23
24	84.0	22.00	52.44	75.0	12.0	40.65	60.0	-2.0	27.91	50.47	96.00	-6.00	102.0	48.98	72.91	51.95	28.04	Nov., 1866	Nov., 1873	3	7	John Fleming, W. T. Kerr	Readington, Hunterdon Co.	24
25	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	May, 1869	June, 1869	...	2	......	White House, Hunterdon Co.	25
26	86.0	40.00	62.83	......	12.0	43.46	66.0	15.0	36.62	53.08	97.00	-12.00	109.0	47.36	73.64	59.15	32.18	Jan., 1857	March, 1858	1	3	J. T. Sergeant	Sergeantville, Hunterdon Co.	26
27	......	......	......	60.0	22.0	39.88	52.0	6.0	33.40	......	......	......	......	......	......	......	33.75	Nov., 1869	Feb., 1870	...	4	John Fleming	Lesser Cross Roads, Somerset Co.	27
28	......	......	......	69.0	11.0	......	62.0	12.0	......	......	......	......	......	......	......	......	......	Nov., 1875	Feb., 1876	...	4	Prof. C. W. Larison, M. D.	Ringoes, Hunterdon Co.	28
29	85.0	25.00	53.53	72.0	4.0	38.19	59.5	-9.0	29.70	49.57	95.00	-11.00	106.0	48.12	69.53	51.57	29.05	Sept., 1878	Dec., 1880	2	4	William J. Morgan	Somerville, Somerset Co.	29
30	72.0	36.00	51.78	80.0	20.0	39.73	52.0	6.0	29.73	......	......	......	......	......	......	52.68	28.77	Jan., 1872	Feb., 1873	...	9	......	Roycefield, Somerset Co.	30
31	84.0	29.00	53.89	74.0	11.0	41.66	65.0	-8.0	30.72	50.78	101.00	-12.00	113.0	48.32	71.80	53.12	29.89	March, 1863	Dec., 1880	11	1	Prof. George H. Cook, George W. Thompson, Agricultural College Farm	New Brunswick, Middlesex Co.	31
32	83.0	21.00	54.96	72.0	4.0	39.30	59.0	-11.0	29.82	50.85	97.00	-11.00	108.0	48.87	71.76	53.43	29.34	Sept., 1878	Dec., 1880	2	1	Prof. Charles G. Rockwood, M. McNeil	Princeton, Mercer Co.	32
33	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Feb., 1877	March, 1877	...	2	Rev. Frank Miller	Pennington, Mercer Co.	33
34	88.6	20.00	51.17	75.5	10.2	41.38	70.0	-16.5	31.75	50.42	101.50	-20.00	121.5	48.59	70.89	51.83	30.36	Jan., 1837	Aug., 1860	23	8	L. H. Parsons	Lambertville, Hunterdon Co.	34
35	83.0	28.00	55.33	74.0	9.0	44.09	64.0	-8.0	32.91	53.15	99.00	-13.00	112.0	51.16	73.97	55.35	32.11	Jan., 1840	Dec., 1880	16	...	Dr. F. A. Ewing, E. R. Cook	Trenton, Mercer Co.	35
36	......	......	53.60	......	......	42.30	......	......	30.87	51.88	......	......	......	50.55	73.03	53.82	30.12	Jan., 1790	Dec., 1859	67	10	—— Pierce, E. Hance	Morrisville, Bucks Co., Pa.	36
37	84.0	30.00	53.80	76.0	17.0	43.30	62.0	4.0	32.87	51.67	99.00	-9.00	108.0	49.15	71.71	54.10	31.72	Jan., 1860	Dec., 1870	11	...	E. Hance	Fallsington, Bucks Co., Pa.	37
38	84.0	32.00	56.25	71.0	8.0	44.37	61.0	-5.0	34.24	51.94	100.00	-5.00	105.0	47.59	71.80	55.54	32.83	Jan., 1874	Dec., 1880	7	...	U. S. Signal Service Observers	Sandy Hook, Monmouth Co.	38
39	......	......	......	......	......	......	......	......	......	......	......	......	......	47.63	68.98	......	......	Jan., 1861	Aug., 1861	...	8	Prof. G. L. Harper	Riceville, Monmouth Co.	39
40	......	......	57.37	......	......	45.73	......	......	34.80	53.50	......	......	......	52.13	70.33	56.50	35.03	June 1831	March, 1849	3	2	Colb and Jenkins	Middletown, Monmouth Co.	40
41	73.0	36.00	54.25	66.0	11.0	41.95	61.0	7.0	37.00	50.92	94.00	-5.00	99.0	45.33	70.07	54.00	34.28	Jan, 1874	June, 1876	2	6	......	Long Branch, Monmouth Co.	41
42	84.0	32.00	......	72.0	12.0	......	66.0	8.0	......	......	......	......	......	......	......	......	......	Aug., 1874	March, 1876	...	...	H. B. Beegle	Ocean Grove, Monmouth Co.	42
43	75.0	26.00	51.40	68.0	8.0	39.70	63.0	5.0	34.50	48.80	95.00	-10.00	105.0	43.30	68.60	51.90	31.30	Jan., 1874	Jan., 1876	2	1	U. S. Signal Service Observers	Squan Beach, Ocean Co.	43
44	82.0	28.00	55.51	73.0	11.0	43.30	63.0	-7.0	34.10	51.22	96.00	......	10.0	47.05	69.83	54.82	33.17	Jan., 1874	Dec., 1880	7	...	U. S. Signal Service Observers	Barnegat, Ocean Co.	44
45	81.0	29.00	56.31	71.0	10.0	44.01	64.0	-7.0	35.03	51.80	99.00	-7.00	106.0	47.50	70.13	55.55	34.03	Jan., 1874	Dec., 1880	7	...	U. S. Signal Service Observers	Atlantic City, Atlantic Co.	45
46	79.0	31.00	58.50	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Oct., 1863	Oct., 1863	...	1	Dr. Somers	Somers Point, Atlantic Co.	46
47	72.0	29.00	54.40	69.0	10.0	41.80	61.0	4.0	35.90	50.48	94.00	-3.00	97.0	45.10	69.10	53.90	33.70	Jan., 1874	Jan., 1876	2	1	U. S. Signal Service Observers	Peck's Beach, Cape May Co.	47
48	......	......	53.54	......	......	44.48	......	......	28.36	52.21	......	......	......	48.24	74.06	55.90	30.66	Jan., 1865	April, 1868	2	...	B. Cole	Seaville, Cape May Co.	48
49	89.0	24.50	53.55	77.0	8.0	41.52	70.0	-11.0	32.58	50.96	99.00	-11.00	110.0	48.09	71.56	53.01	31.26	Jan., 1857	Dec., 1880	11	9	Prof. O. R. Willis, Prof. Charles F. Richardson	Freehold, Monmouth Co.	49
50	73.0	31.00	48.80	76.0	23.0	44.30	......	......	......	......	......	......	......	49.40	......	......	......	Jan., 1876	Nov., 1876	...	8	Peddie Institute	Hightstown, Mercer Co.	50
51	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Jan., 1880	June, 1880	...	6	Eayre Oliphant	New Lisbon, Burlington Co.	51
52	82.0	33.00	54.37	71.0	21.0	44.59	68.0	4.0	34.58	52.22	98.00	0.00	98.0	50.33	71.24	54.76	32.56	Jan., 1861	June, 1876	8	9	Dr. M. J. Rhees, Dr. F. Ashhurst	Mount Holly, Burlington Co.	52
53	86.0	26.00	53.39	78.0	10.0	41.65	71.0	-9.0	31.90	51.83	102.00	-13.00	115.0	49.71	73.22	53.37	31.02	March, 1861	Dec., 1880	18	...	Thomas J. Beans	Moorestown, Burlington Co.	53
54	78.0	27.00	52.23	72.0	19.0	42.98	62.0	2.0	32.59	51.67	102.00	-12.00	114.0	49.42	72.30	53.56	31.38	Jan., 1864	Dec., 1870	6	9	J. S. Lippincott, S. Wood, J. Boadle	Haddonfield, Camden Co.	54
55	88.0	23.00	53.69	82.0	9.0	40.95	67.0	-15.0	33.29	52.34	99.00	-15.00	114.0	50.04	73.49	53.19	32.65	Nov., 1871	Dec., 1880	9	2	H. A. Green	Atco, Camden Co.	55
56	78.0	24.00	51.55	73.0	23.0	43.08	......	......	......	......	......	......	......	......	......	......	......	March, 1868	Nov., 1868	...	9	J. S. Fritts	Elwood, Atlantic Co.	56
57	87.0	22.00	55.42	75.0	15.0	41.94	60.0	5.0	32.61	52.64	101.00	-7.00	108.0	48.49	74.57	54.41	33.09	Oct., 1867	July, 1870	2	10	E. D. Couch	Newfield, Gloucester Co.	57
58	92.0	25.00	54.66	80.0	9.0	42.54	70.0	-10.0	32.53	53.23	106.00	-10.00	116.0	50.69	75.09	54.47	32.68	Jan., 1867	Dec., 1880	14	...	Dr. John Ingram	Vineland, Cumberland Co.	58
59	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	Jan., 1876	Jan., 1876	...	1	J. Kennedy Barton	Florence, Burlington Co.	59
60	......	......	54.43	......	......	44.46	......	......	33.39	51.94	......	......	......	49.71	72.01	54.81	31.22	March, 1849	March, 1868	13	3	Rev. A. Frost, Dr. E. R. Schmidt, J. C Deacon	Burlington, Burlington Co.	60
61	80.0	42.00	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	March, 1877	Oct., 1877	...	9	J. M. Vanhekle	Camden, Camden Co.	61
62	88.0	17.00	54.31	80.0	10.0	43.43	72.0	-5.0	33.68	52.84	101.00	-9.00	110.0	50.65	73.61	54.48	32.63	Feb., 1831	Dec., 1880	49	10	J. A. Kirkpatrick, A. D. Bache and others, U. S. Signal Service Observers	Philadelphia, Philadelphia Co., Pa.	62
63	67.0	30.00	45.33	......	28.0	47.84	68.0	9.0	31.96	......	......	......	......	......	......	......	......	Oct., 1859	Dec., 1859	...	3	G. Watson	Woodstown, Salem Co.	63
64	......	......	......	......	......	......	70.0	22.0	39.00	......	101.00	-4.00	105.0	......	74.60	......	34.52	Jan., 1877	Jan., 1878	...	9	W. B. Matlock	Salem, Salem Co.	64
65	82.0	26.00	53.67	61.0	15.0	38.81	52.0	-6.0	28.42	50.94	103.00	-6.00	109.0	47.49	74.14	53.00	29.12	Nov., 1871	Nov., 1873	2	1	H. C. Perry	Allowaystown, Salem Co.	65
66	88.0	32.00	57.32	75.0	20.0	45.90	65.0	9.0	36.62	54.69	101.00	-5.00	106.0	51.70	75.23	57.61	34.23	Feb., 1825	Sept., 1870	18	10	Assistant Surgeon, U. S. Army	Fort Delaware, Del.	66
67	79.0	29.00	54.23	73.0	17.0	43.67	67.0	1.0	33.71	53.05	95.00	-9.00	104.0	51.00	73.65	54.73	32.83	Jan., 1864	Feb., 1873	9	2	Rebecca C. Sheppard	Greenwich, Cumberland Co.	67
68	83.0	33.00	57.07	76.0	15.0	44.38	70.0	-6.0	35.60	55.03	99.00	-6.00	105.0	52.79	75.59	56.18	35.55	Aug., 1870	Dec., 1880	9	8	J. H. Bateman	Dover, Kent Co., Del.	68
69	......	......	55.68	......	......	41.96	......	......	33.34	52.49	......	......	......	48.18	73.60	54.67	33.50	April, 1868	Nov., 1875	4	1	Mrs. J. R. Palmer	Rio Grande, Cape May Co.	69
70	......	......	58.30	......	......	45.75	......	......	37.08	53.19	......	......	......	48.45	71.77	57.06	35.49	Sept., 1871	Jan., 1880	8	5	U. S. Signal Service Observers	Cape May, Cape May Co.	70
71	89.0	25.00	56.35	78.0	11.0	45.39	73.0	-3.0	35.85	54.71	100.00	-15.00	115.0	52.72	74.83	56.60	34.68	1831	Dec., 1880	45	4	Fort McHenry, Assistant Surgeon, U. S. Army and U. S. Signal Service	Baltimore, Baltimore Co., Md.	71

reports of the Chief Signal Officer, 1870 to 1879, inclusive; the Monthly Weather Review isued from same office; New York Meteorology, *by F. B. Hough, First and Second Series*; the American Almanac, for 1861; and original data furnished by local observers. In the case of nearly all the existing stations the records have been submitted to the observers, and revised by them wherever necessary to correspond with their original records of observations. The mean temperatures are believed to be as nearly correct as it is possible to make them. In the columns for maximum and minimum temperatures, the extremes do not in all cases correspond to the whole length of periods covered by the mean temperatures, as the data were not accessible. It is possible that they do not, therefore, in a few localities, represent the extremes or indicate so wide a range as may have been observed.

In order to a more accurate comparison, the records of mean temperature of Newark and of Morrisville, Pa., where the observing hours are not the ordinary ones, (7 A. M., 2 P. M., and 9 P. M.,) have been corrected to correspond with observations made at those hours.

The temperatures are expressed in degrees and fractions of a degree, and according to the Fahrenheit scale.

NOTE.—Differences arising from variations in the reading of instruments and from their varying exposures have not been taken into account, as they probably neutralize one another to some extent. The proper location for thermometers requires that they be sheltered from the direct rays of the sun, from rain, and against the disturbing influences from radiation, both from bodies warmed by the sun and from radiation to cold bodies. And they should be placed at least 6 feet above the ground, and not higher than 15 feet above it.

Some of the extremes in the table are, no doubt, excessive through errors in position. In careful comparison and in proper location, the U. S. Signal Service Stations afford especially valuable records of temperature.

The *second table* gives the *mean temperature*, by months, seasons, and years, at twenty-four selected stations. The observing periods of these stations are either long (eleven years or more), or are the results of comparisons with Newark and reduction to correspond with the length of the Newark series. The original figures of mean temperatures of the stations, which have been thus corrected, may be found in the first table.

This table is the basis for the diagrams of Plates III A. and III B.

TABLE OF MEAN

By Months and Seasons.

STATIONS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
White Plains, Westchester Co., N. Y.	29.94	30.69	35.14	47.95	58.82	68.37	73.14	69.38	63.03	53.14	41.53	30.72
West Point, Orange Co., N. Y.	28.68	29.60	37.85	49.27	60.68	69.64	74.51	72.57	65.10	54.26	42.96	32.49
Port Jervis, Orange Co., N. Y.	22.87	25.17	32.64	44.83	56.11	63.10	69.35	67.59	59.56	46.68	37.24	29.18
Goshen, Orange Co., N. Y.	25.65	26.31	36.54	47.41	56.22	64.73	68.69	67.64	59.76	48.87	38.78	28.01
Easton, Northampton Co., Pa.	25.27	28.37	36.64	48.32	59.80	69.12	74.35	71.26	64.09	51.36	40.44	29.45
Dodge Mine, Morris Co.	24.95	26.01	31.52	44.53	55.41	62.06	67.48	66.03	58.14	48.84	36.31	28.56
New York City	30.21	31.45	37.54	48.43	59.04	69.62	74.72	73.11	65.42	54.21	44.88	33.00
Newark, Essex Co.	28.51	29.87	37.39	48.31	59.19	68.60	73.96	71.25	63.61	52.39	41.78	31.33
New Germantown, Hunterdon Co.	27.77	28.82	36.15	47.74	59.37	68.77	73.57	70.29	62.60	50.88	39.84	30.36
New Brunswick, Middlesex Co.	28.33	30.63	36.21	49.37	59.39	68.83	74.73	71.85	63.82	53.89	41.66	30.72
Princeton, Mercer Co.	26.90	28.83	35.86	46.29	56.74	66.60	71.35	69.99	63.45	51.78	40.12	31.02
Lambertville, Hunterdon Co.	29.72	29.62	38.27	48.35	59.16	68.37	73.52	70.78	62.93	51.17	41.38	31.75
Trenton, Mercer Co.	31.10	32.33	39.66	52.16	61.67	71.92	75.97	74.01	66.64	55.33	44.09	32.91
Morrisville, Bucks Co., Pa.	30.08	29.41	38.23	50.63	62.80	71.45	75.36	72.30	65.57	53.60	42.30	30.87
Sandy Hook, Monmouth Co.	31.28	31.83	37.66	46.09	56.66	66.33	72.20	71.46	65.17	55.20	45.37	35.18
Barnegat, Ocean Co.	31.81	32.43	38.21	45.77	54.80	64.05	69.72	70.40	64.83	54.46	44.20	35.04
Atlantic City, Atlantic Co.	32.60	33.30	38.65	46.50	54.98	64.42	69.67	70.96	65.51	55.26	44.91	35.97
Freehold, Monmouth Co.	30.09	31.10	38.00	46.60	59.46	69.29	73.81	71.58	63.97	53.55	41.52	32.58
Moorestown, Burlington Co.	29.72	31.44	38.38	49.91	60.85	70.91	75.68	73.06	65.06	53.39	41.65	31.90
Vineland, Cumberland Co.	31.98	33.54	39.32	50.71	62.03	73.21	77.90	74.17	66.21	54.66	42.54	32.53
Philadelphia, Pa.	31.50	32.72	40.10	50.43	61.43	71.21	76.11	73.51	65.70	54.31	43.43	33.68
Greenwich, Cumberland Co.	32.69	34.14	40.90	50.63	61.37	70.87	76.20	73.44	66.01	54.93	44.15	35.25
Cape May, Cape May Co.	34.61	35.35	41.03	48.59	56.68	66.45	72.07	71.56	66.97	57.42	47.42	37.99
Baltimore, Md.	33.53	34.86	42.06	52.84	63.26	72.23	77.14	75.12	68.05	56.35	45.39	35.85

TEMPERATURE.

Expressed in degrees and fractions of a degree.

Year.	Seasons. Spring.	Seasons. Summer.	Seasons. Autumn.	Seasons. Winter.	March of Seasons. Winter to Spring.	March of Seasons. Spring to Summer.	March of Seasons. Summer to Autumn.	March of Seasons. Autumn to Winter.	Difference between Summer and Winter.	Period of Observation. Length.
50.15	47.30	70.29	52 51	30 45	16.85	22.99	17.78	22.06	39.84	15 Years and 6 Months.
51.47	49.27	72 24	54 11	30.26	19.01	22.97	18.13	23.85	41.98	46 Years and 5 Months.
46.19	44.53	66.68	47.83	25.74	18.79	22.15	18.85	22.09	40.94	Compared with Newark and Reduced.
47.38	46.72	67.02	49 13	26.66	20.06	20.30	17.89	22.47	40.36	11 Years.
49.88	48.25	71.58	51.99	27.70	20.55	23.33	19.59	24.29	43.88	Compared with Newark and Reduced.
45.82	43 82	65.19	47.76	26.51	17.31	21.37	17.43	21.25	38.68	Compared with Newark and Reduced.
51.80	48.34	72.48	54.83	31.55	16.79	24.14	17.65	23.28	40.93	31 Years and 11 Months.
50.52	48.30	71.27	52.59	29.92	18.38	22.97	18.68	22.67	41.35	37 Years and 8 Months.
49.67	47.75	70.88	51 11	28 95	18.80	23.13	19.77	22.16	41.93	Compared with Newark and Reduced.
50 78	48.32	71 80	53.12	29.89	18.43	23.48	18.68	23.23	41 91	11 Years and 1 Month.
49.08	46.30	69.31	51.78	28.92	17.38	23.01	17.53	22 86	40 39	Compared with Newark and Reduced.
50.42	48.59	70 89	51.83	30.36	18.23	22.30	19.06	21.47	40.53	23 Years and 8 Months.
53.15	51.16	73 97	55.35	32.11	19.05	22.81	18.62	23.24	41.86	16 Years.
51.88	50.55	73 03	53.82	30.12	20.43	22.48	19.21	23.70	42.91	67 Years and 10 Months.
51.19	46.81	70.00	55.21	32.76	14.05	23.19	14.79	22 45	37.24	Compared with Newark and Reduced.
50.48	46.26	68.06	54.49	33.09	13.17	21.80	13.57	21 40	34.97	Compared with Newark and Reduced.
51.06	46.71	68.35	55.22	33 96	12 75	21.64	13.13	21.26	34.39	Compared with Newark and Reduced.
50.96	48.09	71.56	53.01	31.26	16.83	23.47	18.55	21.75	40.50	11 Years and 9 Months.
51.83	49.71	73 22	53.37	31.02	18.69	23.51	19.85	22.35	42.20	18 Years.
53.23	50.69	75.09	54.47	32.68	18.01	24 40	20.62	21.79	42.41	14 Years.
52.84	50.65	73.61	54.48	32.63	18 02	22.96	19.13	21 85	40.98	49 Years and 10 Months.
53.88	50.97	73.50	55.03	34.03	16.94	22.53	18.47	21 00	39.47	Compared with Newark and Reduced.
53.01	48.77	70.03	57.27	35.98	12.79	21.26	12.76	21 29	34.05	Compared with Newark and Reduced.
54.71	52.72	74.83	56.60	34.68	18.04	22.11	18.23	21.92	40.15	45 Years and 4 Months.

EXPLANATION OF PLATES IIIA. AND IIIB.

Diagrams of Mean Temperature.

The stations are represented by vertical columns, sections of which express, by their lengths, the increments and decrements of heat for the several months of the year. In Plate IIIA. the increments appear in *ascending* order, beginning with January. In IIIB. the decrements are in a *descending* order, beginning with July. January and July appear in both, as these months are the extremes at all stations, with two exceptions. The sections representing the months are indicated by black for January and various systems of lining for the other months.

In these diagrams we see, therefore, the gradual increase of heat through the first half of the year and then the decrease in the second half. The variations in length express the varying increase or decrease. Thus, the sections for February are very short, inasmuch as the mean temperature but slightly exceeds that of January. The decline from July to August is also short, as the difference between the months is small. The other months are shown by longer sections, standing for greater differences. The comparative heights for January show the relative degree of cold in the coldest winter month, and, likewise, those of July indicate the extreme heat of the summer at the several stations. The diagrams give us, therefore, a graphic representation of the mean temperatures by months at each place and enable us to compare not only these means, but the increments and decrements also.

The figures at the sides give the degrees and the whole is drawn to a vertical scale.

WINDS.

The prevailing winds in New Jersey come from the west. In the warmer months they are more southerly, coming from the southwest quarter; in the colder months the northwest winds prevail. The relative frequency of winds blowing from the several quarters, is given in the following table of their respective percentages, made from 20,696 observations at Easton, Pa., Newark, Lambertville and Burlington, during the period 1854–1859, inclusive:

PLATE III (A)

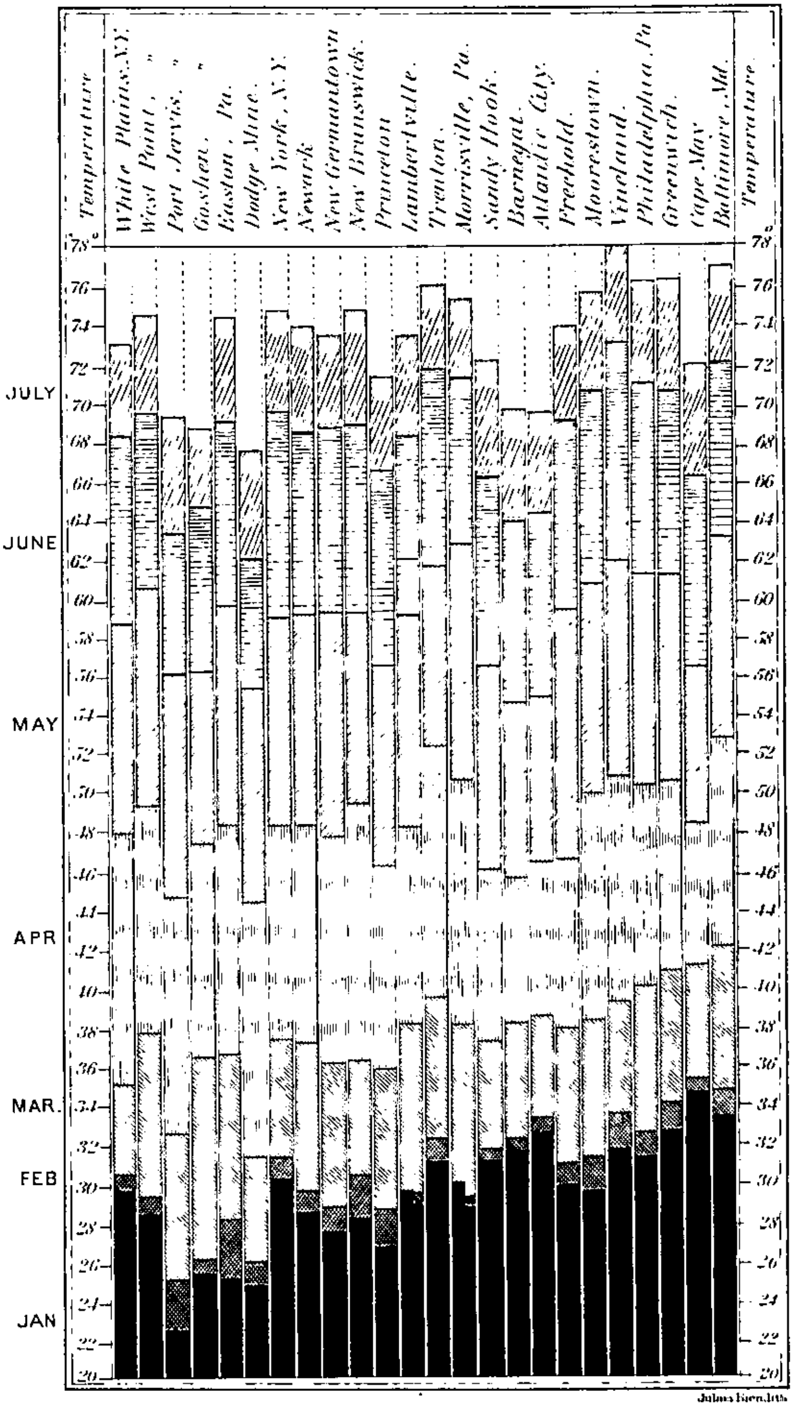
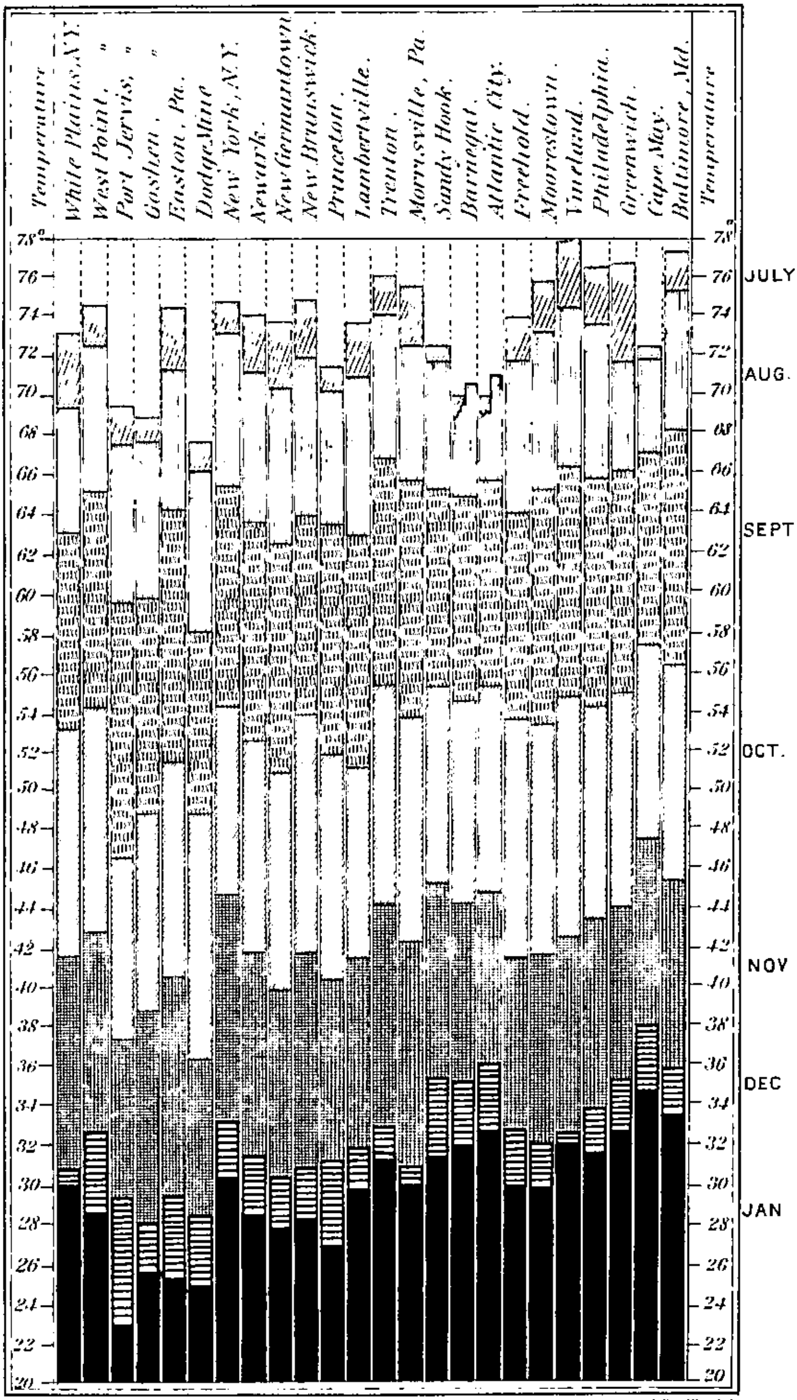


Diagram showing Mean.

PLATE III.(B)



Temperature by Months.

North	6.46	per cent.
North and east	14.17	"
East	3.29	"
East and south	9.72	"
South	6.20	"
South and west	20.57	"
West	13.77	"
West and north	25.82	"
	100.00	

The following records of observations on direction of winds are tabulated, viz.:

1. New Brunswick, 1876-1880 .... 5 years.
2. Vineland, 1866-1880 .... 15 "
3. Atlantic City, July, 1876, to July, 1879 .... 3 "

WINDS.	NEW BRUNSWICK.	VINELAND.	ATLANTIC CITY.
	Per cent.	Per cent.	Per cent.
North	10.01	3.2	9.0
Northeast	11.80	13.9	11.7
East	5.59	2.0	8.3
Southeast	3.60	11.8	6.3
South	7.82	3.3	17.4
Southwest	21.42	34.1	15.9
West	27.08	6.4	16.1
Northwest	12.68	25.3	15.3
	100.00	100.0	100.0

Or, the east *quarters* are to the west, at New Brunswick, as 1 : 2.9, and the north to south are as 1 : 1 (nearly).

At Vineland, the easterly are to the westerly winds as 1 : 2.4, and north to south as 1 : 1.19.

At Atlantic City, the ratios are, east to west as 1 : 1.8, and north to south as 1 : 1.1.

We note, in these figures, that at Vineland there is a greater frequency of south winds, as compared with New Brunswick. And this increase is in harmony with the generalization that, going southward on our Atlantic slope, there is a gradual increase in the percentage of winds blowing from south quarters.

The Atlantic City observations show a relatively greater number of winds from the eastern quarters. The sea breezes, no doubt, account for much of this increase.

The observations at New Brunswick, when examined by months, show that the southwest, south, southeast and east winds blow more frequently in the warmer months, April to October. The northeast wind is more often observed in winter and spring. The north, northwest and west winds prevail more in the autumn and winter.

The observations do not, however, show fully the relative prevalence of the west winds, unless we take into account the distance traveled by them. The mean velocity of the northwest winds exceeds that of the west, southwest, or winds from other quarters. Observations ought not to be limited to direction only, but should include velocity and measure the distance traveled, also.

The prevalence of west winds is a feature of the climate common to the Atlantic slope. The distribution of pressure, and the difference of temperature on the land and sea, produce the more northern winds in the winter months, and the southern in the summer. In the winter the high pressure in the interior of the continent sets in motion the air currents which flow southward or southeast, towards the ocean. The reverse is the case in the summer, as then the highest pressure is to the south, and the winds are from that quarter. The disturbing agents which modify these general directions, are nearly all due to the passage of storm centers across our territory, or to one or the other side of it. The storms accompanied by low barometric pressure move across the country from southwest to northeast, entering from the Gulf of Mexico and passing northward and north-northeast to the St. Lawrence region and the New England coast. Others come from the northwest and west, and pass in a general east or east-northeast course to the ocean. Occasionally their origin is in the region of the Great Lakes, and then the movement may be eastward, or southeast to the coast. The tracks of these low barometers for several years past have been charted by the U. S. Signal Office, and their maps indicate the direction, rate of movement and rainfall accompanying their progress. The varying positions of these storm centers, and the inflowing air currents, give rise to the winds observed during the progress of our storms. The general succession is from southeast to east, northeast, north and northwest on clearing, or in the reverse order from that of the hands of a watch. These storm-winds are so prominent features of our climate, and they are so closely studied by all weather observers, that it is not necessary here to discuss more fully their successive phases. The easterly winds are, in general, our rain-bearing winds, while the west winds are accompanied by clear weather, excepting the more local showers and generally shorter storms of the summer months.

The mean direction of the winds for each month, as deduced by Prof. Coffin, from observations at 40 different places in Delaware, Southeastern Pennsylvania and Southern New Jersey, is given in the following table:

January	N. 81° W.	July	S. 83° W.
February	N. 78° W.	August	S. 64° W.
March	N. 83° W.	September	N. 89° W.
April	S. 89° W.	October	N. 88° W.
May	S. 89° W.	November	N. 79° W.
June	S. 84° W.	December	N. 79° W.

"Here, as generally, on the middle Atlantic coast, the change in the mean direction is slight, the wind being westerly in all months, and the difference but 38° between February, when the winds incline most to the north, and August, when the most southerly direction is reached."*

The mean direction of the winds in the four seasons in Southeast New York, Eastern Pennsylvania, and North and Central New Jersey, are given in Prof. Coffin's tables.

	Spring.	Summer.	Autumn.	Winter.
Southeastern New York	N. 80° W.	S. 43° W.	N. 77° W.	N. 60° W.
North and Central New Jersey	N. 55° W.	S. 69° W.	N. 69° W.	N. 58° W.
Eastern Pennsylvania	N. 68° W.	S. 75° W.	N. 72° W.	N. 55° W.

*"Discussion and Analysis of Prof. Coffin's Tables and Charts of the Winds of the Globe," by Dr. Alexander J. Woeikoff, Smithsonian Contributions to Knowledge, No. 268. Washington, 1876.

The western side of the State is represented by Eastern Pennsylvania.

In mountainous regions the winds are generally controlled in their directions by the courses of the valleys and of the mountain ranges. The prevailing winds take the valleys, and they are said to blow up or down them. In New Jersey our mountains are too low, and the valleys are not deep enough to have much effect in diverting the course of the winds, excepting in some of the very narrow depressions and over very limited areas. The southeastern slopes of some of the Highland ranges are thus shielded from the cold and northwest winds of winter. But the aggregate area of such sheltered localities is small, compared with that of the whole Highlands.

The proximity of the ocean gives rise to another disturbing agency, which is due to the different heating capacities of land and water and it appears in the

SEA BREEZES.—Along our coast there is a belt of varying breadth in which the general direction of the wind is interrupted, during the warmer part of the year, by the inflowing currents of sea air, which are known as sea breezes. They are periodic, coming daily, with rare exceptions. They are caused by the unequal heating of the land and water surfaces. The air over the land is heated and expands, giving rise to ascending currents. To restore the average density and to maintain an equilibrium, the cooler air over the water flows toward the land, producing an *on-shore wind.* This movement begins usually near midday, or sometimes about 11 o'clock, gradually increasing in force, until it attains a maximum velocity about 2 o'clock in the afternoon. It then lessens (as the land cools more rapidly) and ceases about nightfall, when the land or *off-shore* wind takes its place. This daily recurrence of the sea breeze is the peculiar feature of our shore, which moderates the heat, and by its invigorating sea air makes the seaside so attractive both to the pleasure-seeker and the invalid. It affects the temperature, and hence the maximum for the day at the seaside is not about 2 to 3 o'clock as in the interior, but about noon or just before its arrival. Occasionally there is a summer day when the land wind prevails and there is no sea breeze. They are known as hot days at the shore, and probably because of the contrast with the cooler days when the sea breeze prevails. The influence of the sea breeze upon the high temperatures, and also upon the mean temperatures of the summer months, is best seen in a comparison of these as observed at stations on the coast and at localities inland. The description of the Atlantic coast belt and of the Cape May peninsula (pp. *30, *40, *41) contains results of such comparisons.

The extent or limit to which sea breezes are felt from the coast line, varies considerably, according to the direction of the shore line and the contour of the surface. There is a variation in the same season and in different seasons, according to the character of the same. Generally the distance is less than ten miles, and often not more than four or five miles. Its regular recurrence is limited to the shorter distance, or to a narrow shore belt. Cleared land surfaces which are readily heated and where there are no obstructions in the form of timber belts, allow of a further indraught of the sea breeze. The absence of hills along our coast favors its progress. Long-continued hot weather, as in summer droughts, which allow an accumulation of heat in the surface soil and the lower air stratum, seems to widen the belt considerably, and for many days together the breeze is observed at places further inland, beyond its ordinary limit, coming, however, later in the afternoon than it does on the shore. Such daily winds are often observed at New Brunswick, and other places in Middlesex and Monmouth counties which are ten to fifteen miles from the ocean.

The height to which the sea breeze reaches has been determined very recently by balloon ascensions, and observations made at Coney Island, N. Y., in August, 1879, and reported with notes by O. T. Sherman, in the "American Journal of Science," Vol. XIX., pp. 300–302. The surface breeze was found to cease at a height of about 650 feet, and at 700 feet a land current deflected the breeze towards the northwest. At 800, 900, 1,000, 1,100 and 1,200 feet, the observations, with one exception, indicated winds from the northwest quarter. Under 700 feet the prevailing directions were southerly, and from both the southeast and southwest quarters. The extension of observations of this kind to points on the New Jersey coast, would be interesting and add to our knowledge of this phenomenon.

The total movement of the air, or distance traveled, varies with the velocity and duration of the wind.

In the interior of the State the winds are not often high, nor do they blow steadily at a given rate for a long time. Everywhere our winds may be termed variable, shifting slightly from point to point, and varying in their velocity. In the summer they are more gentle than in the other seasons of the year. And short seasons of calms are not uncommon. The more violent and high winds come with thunder storms. The spring and winter are marked by more windy weather, and by a greater total movement of the air. Hurricanes are unknown, and there are very few records of what may be termed tornadoes. That of June 13th, 1835, at New Brunswick, was probably the most destructive one ever felt in the State since records of such phenomena have been made.* Generally, the damaging effects of high winds are confined to narrow limits, and rarely do more than throw down crops and partially decayed trees, or occasionally unroof a building. Destructive winds, such as are reported from the Southern and Western States, are here unknown.

On the shores of our Atlantic coast and Delaware bay divisions the winds blow more steadily, and the velocity is generally greater than it is inland, where the mountains or wood serve to retard the air movement. The more isolated high peaks or crests of the Highlands are, possibly, more exposed than the coast stations, but we have no records from them. Observations and measurements elsewhere indicate this to be a fact. But at Cape May the U. S. Signal Office Station records frequently give a greater total movement than that of any other of their stations in the country, excepting Mount Washington and Pike's Peak. The total movement of the air at Cape May for one month (December, 1878,) has amounted to 16,567 miles, or an average of 22 miles per hour for every hour of that month. In the winter and spring months the totals are from 9,000 to 13,000 miles, whereas in the summer months they are under 10,000 miles, and rarely exceed 9,000. The autumn months give a wider range.

At Sandy Hook, 16,954 miles were measured in December, 1876, a slight excess over Cape May. Generally, the totals for Sandy Hook are a few hundreds or a thousand miles below those of Cape May. Philadelphia, Baltimore and New York rarely report more than 9,000 miles for any month. From the "Monthly Weather Review" it appears that Cape May is the most windy of all the U. S. Signal Office Stations, except Mt. Washington and Pike's Peak.

*Blodgett's Climatology of the United States, page 403.

Its position between the ocean and the bay may explain this large total air movement.

High velocities also are frequently reported from these coast stations. Rates over 50 miles per hour are quite common. At Sandy Hook, December 9th, 1876, the rate of 84 miles was observed. At Cape May, 83 miles were recorded of a northwest wind in November, 1879; 72 miles of a west wind, December 9th, 1876, and 65 miles of a wind in September, 1876. The duration of high winds, having these velocities, is short. They are the peculiar features of severe storms which move northeastward along our coast, and generally belong to the clearing-up period of the storm as it is moving away.

No records of movements or velocities from the northern or central parts of the State are known, but it is not likely that any such figures as are given here would be measured, unless on mountain tops.

RELATIVE HUMIDITY.

Atmospheric air always contains some vapor of water, or moisture in addition to its oxygen, nitrogen and carbonic acid gas.

When fully saturated, each cubic foot of air, at 80° temperature, holds	10.81	grains of vapor of water.
One cubic foot, at 60°, holds	5.87	" "
Difference	4.94	" "

Therefore, when cooled from 80° to 60°, 4.94 grains will be thrown down or deposited in a liquid form as rain, or, if colder, as snow or hail. The height of the mercurial column which is sustained by the vapor of water in the air, when saturated, at different temperatures, varies as follows:

At 32°	0.181	inch.
At 60°	0.518	"
At 80°	1.023	"
At 100°	1.918	"

The capacity is, therefore, about doubled for each rise of about 20°. Using the saturated condition or state as the standard of comparison (100), the relative quantity of moisture is expressed by percentage. The drier the air, the lower the percentage, and conversely. It is possible to make comparisons between localities, or between the different states of the air at any given place, expressing the differences in such terms of percentage. It is in such comparisons that the term *relative humidity* is employed. The instrument to measure the quantity of vapor of water, is a hygrometer, and from its readings the relative humidity is calculated.

In consequence of the ever-varying rates at which the processes of evaporation and condensation go forward, the quantity of moisture in the air is subject to continual change. The extent of water surface, the elevation above ocean level, the direction of the prevailing winds, and the temperature, all combine to modify these processes and to increase or diminish the quantity of moisture. Oceanic and insular climates are generally moist or *humid*, whereas continental climates are dry. The mean relative humidity is greater on the seashore than inland.

The influence of great humidity upon vegetable growth, upon temperature and on the healthfulness of localities, is such that the determination is necessary to a full understanding of their climates. The luxuriance of tropical vegetation is generally associated with moist climates. The effect upon temperature is to make it more even, and moist climates are more equable. The moisture in the air, when it approaches saturation, tends like a screen to prevent excessive radiation at night, and to protect from the sun's rays during the day. The air itself is thereby warmed.

Although so important, the accurate determination of this important element is somewhat involved in uncertainty, since variations are found to be considerable within comparatively short distances.*

The following table is here inserted, to show the mean or *average* relative humidity at seven of the U. S. Signal Service Stations within or near our borders. The figures are means computed from data furnished from the office of the Chief Signal Officer. They are given by months and the year. The period of observation was from July, 1877, to December, 1880, inclusive.

* Dr. Heinrich Wild, the eminent Russian Meteorologist, says, in the "Repertorium fur Meteorologie," Band VI., 1879, that there is no *efficient* and *simple* instrument for measuring the relative humidity of the air.

TABLE

Of Mean Relative Humidity for Period July, 1877, to December, 1880—3 Years and 6 Months.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
New York, N. Y..	74.8	73.1	68.8	64.7	64.2	68.8	63.7	72.2	71.8	68.3	68.0	71.5	69.1
Sandy Hook........	78.1	74.8	72.7	72.5	70.0	71.7	74.9	76.8	74.6	71.1	70.8	73.5	73.4
Barnegat	80.2	74.1	75.7	75.7	76.2	78.4	81.8	81.2	78.3	76.6	75.3	79.3	77.7
Atlantic City.......	80.9	77.4	76.6	76.7	77.3	81.0	83.2	82.3	81.3	78.4	74.9	78.2	79.0
Cape May...........	77.2	74.3	74.7	75.5	73.2	75.0	77.9	77.3	76.1	73.3	69.1	73.7	74.8
Philadelphia, Pa...	74.8	70.5	67.6	62.1	61.8	66.3	66.9	70.6	70.0	67.6	68.6	73.4	68.3
Baltimore, Md......	71.3	66.7	64.2	57.0	59.8	62.8	64.9	68.5	69.9	67.4	65.7	67.7	65.5

The table shows that the inland localities, as Baltimore and Philadelphia, are drier than the coast stations.

Another remarkable fact is the difference in the seasons. At New York, Philadelphia and Baltimore, the mean humidity for the four months of December to March, exceeds those for the four months of June to September. At the coast stations the reverse is true, and these latter are the more humid or moist months. The curves for the annual fluctuation, when plotted for the several stations, in the case of Atlantic City and Barnegat, rise from May onward to July, and then gradually sink to November. The rise to January is gradual. The curves for Cape May and Sandy Hook show a rise in April and then a depression in May. At the other stations there is no rise in April, but a gradual descent from January to May.

ATMOSPHERIC PRECIPITATION.

RAIN AND SNOW.

The mean quantity of atmospheric moisture precipitated in the form of rain and snow in any district of country is dependent upon its situation, prevailing winds, configuration of surface and the nature of the surface covering. The total amount of atmospheric precipitation is one of the measures of the climate. And according as this amount is distributed throughout the year, and is excessive or very light, climates are said to be wet and rainy, or dry and parched. It is second only in importance, after temperature. The temperature and humidity of the atmospheric air are capable of measurement at regular and frequent intervals, and hence it is comparatively easy to get averages or mean results within much shorter periods than can be obtained in the measurements of the rainfall. Thus, a month may pass without a single rain. The possible error is, therefore, much greater in the short records of rainfall than it is in temperature. The limits, area and configuration of the surface of the climatic divisions of New Jersey have been described under the head of temperature. The direction and relative frequency of the winds and their succession in the course of the storm-centers crossing the State, have also been stated. They are intimately connected with the rainfall, both in its quantity and its distribution throughout the year. The probable limits of error in short periods and the slight differences in amount in these different divisions or climatic provinces, make it impossible to connect the results with these several modifying agencies and show their relative effect. There is urgent need of more widely-distributed and long records in order to arrive at results which may be even suggestive.

As has been said of the larger area of the eastern United States, "the distinguishing feature of the distribution * * * is its symmetry and uniformity in amount over larger areas."* It is possible to construct rain charts, using the longer records only. And such charts of the United States have been published by the Smithsonian Institution and the United States Signal Office. The mean annual rainfall for that portion of the Atlantic slope occupied by New Jersey, ranges from 40 inches at the south to 44 inches in the northern

* Blodgett's "Climatology of the United States," p. 317.

and central portions of the State. These figures correspond with those of the Middle Atlantic generally. In the South Atlantic and Gulf States the mean annual quantity is somewhat greater. The consideration of some of the figures given in the following table will show that there are some differences both in the total quantity for the year and in its distribution by months. Fifty-two places are given in this table. For the Highlands, there is a valuable record at Lake Hopatcong. It was kept by the Morris Canal Company, and for 24 years (1846–1869). West Point and Goshen, N. Y., and Easton, Pa., have been added to represent the Highlands valleys and the Kittatinny valley. New York City and Fort Columbus give long records for comparisons. In the Red Sandstone plain there are comparatively long records at Newark, New Brunswick and Lambertville. The Morrisville and Philadelphia records are used as they are so near our borders, and are of great length. In the Southern Interior, we have good records from Moorestown and Vineland. Dover, Del., and Baltimore, Md., have been added for comparisons with the Greenwich record, which is short. The Atlantic coast and Cape May are unfortunately represented by seven to ten-year periods only. As they cover the same years nearly, it is, however, possible to compare them with one another. The difference of latitude between the extreme northern and the extreme southern stations of the table amounts to 2° 28′, or about 170 miles.

TABLE OF MEAN AMOUNT OF PRECIPI-

For each Month, Season and the Year.

STATIONS.	Latitude.	Longitude.	Height—feet.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1 White Plains, Westchester Co., N. Y.	41° 02′	73° 46′	200	......	......	......	......	......	......	......	......	......	......	......	......
2 West Point, Orange Co., N. Y.	41° 24′	73° 57′	167	3.49	3.22	3.25	4.11	4.98	3.50	4.28	5.18	3.31	4.21	4.07	4.05
3 Goshen, Orange Co., N. Y.	41° 23′	74° 20′	425	2.59	2.55	2.61	2.05	3.44	3.27	2.95	2.66	2.79	3.13	2.34	3.44
4 Port Jervis, Orange Co., N. Y.	41 22′	74° 42′	450	2.65	2.73	2.94	4.25	1.22	2.31	3.90	3.29	2.53	1.70	2.50	1.88
5 Deckertown, Sussex Co.	41° 12′	74° 36′	470	1.94	2.41	2.86	2.16	2.73	......	......	2 92	2.47	......	......	......
6 Newton, Sussex Co.	41° 04′	74° 45′	659	4.05	1.88	4.89	1.79	3.57	3.48	1.92	......	......	......	......	2.45
7 Lake Hopatcong, Morris Co.	40 55′	74° 39′	914	2.37	2.44	2.79	3.47	4.67	3.66	3.95	4.31	3.98	3.77	3.67	3.46
8 Dover, Morris Co.	40° 54′	74° 34′	575	4.11	3.12	2.55	2.57	7.62	8.28	5.00	7.75	5.43	2.87	2.25	3.78
9 Dodge Mine, Morris Co.	41° 01′	74° 35′	1,100	3.01	3.18	4.61	3.69	1.13	2.75	7.22	4.75	2.70	2.54	2.04	1.47
10 Easton, Northampton Co., Pa.	40° 43′	75° 16′	340	2.97	2.58	3.27	3.48	5.57	3.91	3.96	3.98	3.74	3.09	4.66	4.35
11 New York City, New York.	40° 42¾′	74° 00′	164	2.96	2.70	4.40	3.53	2.43	2.99	5.05	5.46	3.12	3.24	3.77	2.96
12 Fort Columbus, N. Y. Harbor.	40° 42′	74° 01′	20	3.03	2.77	3.30	3.34	4.71	3.76	3 41	4.78	3.36	3.30	3.41	4.07
13 Jersey City, Hudson Co.	40° 43′	74° 03′	20	3.16	3.00	4.53	4.10	2.71	3.14	5.11	5.45	3.61	2.99	3.77	2.65
14 Paterson, Passaic Co.	40° 56′	74° 10′	60	3.46	3.27	5.26	3.37	2.89	3.10	7.08	6.56	3.06	2.80	3.89	5.25
15 Bloomfield, Essex Co.	40° 48′	74° 12′	120	3.39	2.99	2.68	4.05	4.61	3.61	4.19	4.54	2.41	3.30	3.47	3.11
16 Newark, Essex Co.	40° 44′	74° 10′	35	3.49	3.36	3.81	3.83	3.98	3.49	4.39	5.47	3.59	3.62	3.73	3.80
17 East Orange, Essex Co.	40° 46′	74° 12′	160	2.65	2.17	4.08	4.56	2.47	3.43	4.62	5.61	2.22	5.05	5.77	4.83
18 Orange, Essex Co.	40° 47′	74° 13′	185	1.10	2.55	3.55	5.12	2.98	3.45	6.70	5.43	5.50	3.70	3.27	3.13
19 South Orange, Essex Co.	40° 45′	74° 15′	140	3.43	2.95	4.10	3.45	2.62	2.80	5.15	5.97	3.56	3.70	3.64	3.72
20 Linden, Union Co.	40° 37′	74° 15′	25	4.09	2.31	4.30	2.89	2.31	2.78	5.10	5.35	3.09	2.81	4.47	3.45
21 New Germantown, Hunterdon Co.	40° 41′	74° 45′	320	3.08	2.78	3.76	3.24	3.29	4.03	4.71	4.95	3.13	5.01	3.67	2.44
22 Readington, Hunterdon Co.	40° 34′	74° 43′	[90]	3.62	4.30	3.01	4.65	4.07	1.52	7.65	6.84	3.24	6.52	4.05	4.27
23 Somerville, Somerset Co.	40° 34′	74° 36′	65	2.50	1.90	4.40	4.38	1.46	3.93	7.53	6.96	1.83	3.06	3.48	5.31
24 New Brunswick, Middlesex Co.	40° 29′	74° 27′	90	3.07	2.97	3 88	3.78	3.82	3.89	4.63	4.94	3 39	3.33	3.64	3.41
25 Princeton, Mercer Co.	40° 21′	74° 39′	220	2.86	2.29	4.55	4.95	1.82	1.41	11.13	3.21	3.11	1.88	2.54	4.63
26 Ringoes, Hunterdon Co.	40° 25′	74° 52′	248	2.52	2.84	5.34	2.71	2.10	3.87	5.80	5.24	4.11	3.32	3.97	3.93

TATION IN RAIN AND MELTED SNOW.

Depth in Inches and Fractions of Inches.

	Seasons. Spring.	Summer.	Autumn.	Winter.	Year.	Series. Beginning.	End.	Length. Yrs.	Mos.	Observers.
1	....	....	....	....	59.830	1873	1880	8	...	Prof. O. R. Willis.
2	12.34	12 96	11.59	10.76	47.650	Jan., 1840	Dec., 1859	20	...	Assistant Surgeon U. S. Army.
3	8.10	8.88	8.26	8.58	33.820	Jan., 1835	Dec., 1849	8	...	New York University System.
4	8.41	9.50	6.73	7.26	31.900	Jan., 1880	Dec., 1880	1	...	Charles F. Van Inwegen.
5	7.75	....	....	....	....	Jan., 1880	Sept., 1880	...	7	A. C. Noble.
6	10.25	....	....	8.38	....	Dec., 1868	July, 1869	...	8	Dr. Thomas Ryerson.
7	10.93	11.93	11.42	8.26	42.540	Jan., 1846	Dec., 1869	24	...	Morris Canal Co., W. H. Talcott, Engineer.
8	12.74	21.03	10.55	11.01	55.330	Nov., 1866	Jan., 1869	2	2	H. Shriver.
9	9.43	14.72	7.28	7.66	39.090	Jan., 1880	Jan., 1881	1	...	Wm. Allen Smith.
10	12.32	11.85	11.49	9.90	45.560	Apr., 1846	Dec., 1859	5	1	—— Green, S. J. Coffin, G. S. Houghton.
11	10.36	13.50	10.13	8.62	42.610	Jan., 1871	Dec., 1880	10	...	U. S. Signal Service Observers.
12	11.35	11.95	10.07	9.87	43.240	Jan., 1836	Dec., 1859	24	...	Assistant Surgeon U. S. Army.
13	11.34	13.70	10.37	8.81	44.220	Mar., 1871	Mar., 1877	6	...	Thomas T. Howard, Jr.
14	11.52	16.74	9.75	11.98	49.990	Jan., 1878	Dec., 1880	3	...	John T. Hilton.
15	11.34	12.37	9.18	9.49	42.380	Mar., 1849	Dec., 1862	10	4	R. L. Cooke.
16	11.71	13.35	10.94	10.68	46.217	May, 1843	Dec., 1880	37	8	Wm. A. Whitehead.
17	11.11	13.66	13.04	9.15	46.960	June, 1877	Sept., 1879	1	10	Thomas T. Howard, Jr.
18	11.65	15.58	12.47	6.78	46.480	Jan., 1872	Dec., 1874	2	8	Dr. W. H. Stockwell.
19	10.17	13.92	10.90	10.10	45.090	Sept., 1870	Dec., 1880	10	3	Dr. Wm. J. Chandler.
20	9.50	13.23	10.37	9.85	42.950	Sept., 1876	Dec., 1880	4	4	Arthur B. Noll.
21	10.29	13.69	11.81	8.30	44.090	Nov., 1868	Aug., 1876	7	10	Arthur B. Noll.
22	11.73	16.01	13.81	12.19	53.740	Dec., 1866	Nov., 1873	1	9	John Fleming, W. T. Kerr.
23	10.24	18.42	8.37	9.71	46.740	Sept., 1878	Dec., 1880	2	4	William J. Morgan.
24	10.98	13.46	10.36	9.45	44.250	Jan., 1854	Dec., 1880	27	...	P. Vanderbilt Spader, Agricultural College Farm, Prof. Geo. H Cook, Geo. W. Thompson.
25	11.32	15.75	7.53	9.80	44.380	Sept., 1878	Dec., 1880	2	1	Prof. Chas. G. Rockwood, M. McNeil.
26	10.15	14.91	11.40	9.29	45.750	Jan., 1876	Dec., 1880	5	...	Prof. C. W. Larison.

TABLE OF MEAN AMOUNT OF PRECIPITATION

For each Month, Season and the Year.

STATIONS.	Latitude.	Longitude.	Height—feet.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
27 Lambertville, Hunterdon Co.	40° 22′	74° 57′	96	3.22	3.12	3.22	3.19	4.29	3 38	4 07	4.94	3 90	3.41	3.21	3.87
28 Trenton, Mercer Co.	40° 14′	74° 45′	60	3.25	2.59	3.87	3.86	3 10	4.01	5.61	5 39	3.61	3.67	4.43	3.11
29 Morrisville, Bucks Co., Pa.	40 13′	74° 52′	30	3.29	2.77	3.33	3.87	3.94	4.09	3.62	4.05	3.48	3.65	4.28	3.29
30 Sandy Hook, Monmouth Co.	40 [illegible]	74° 01′	30	3.67	2.78	6.08	5.22	3.50	4.12	4.95	5.65	4 56	3.21	4.95	4.05
31 Riceville, Monmouth Co.	40 [illegible]	74 [illegible]	200	5.68	2.32	3.61	4.52	5.74	2 00	1.65	2.61	......	......	......	......
32 Middletown, Monmouth Co.	40 [illegible]	74° 10′	111	5.72	2.55	1.16	2.50	4.50	4.10	3.40	1.70	2.50	4.00	3.13	1.37
33 Long Branch, Monmouth Co.	40° 18′	73° [illegible]	28	3.59	3.76	5.71	6.48	3.34	3 28	5.30	7.07	7.52	3.28	5.32	3.68
34 Squan Beach, Ocean Co.	40° 08′	74° 01′	23	3.71	3 03	4.79	8.31	2.98	3.76	4.39	6.20	8.31	2.73	5.50	3.88
35 Barnegat, Ocean Co.	39 45′	74 09′	20	4.13	2.77	5.43	4.49	2.46	3.67	4.62	4 66	4.49	3.04	5.26	4.78
36 Atlantic City, Atlantic Co.	39 [illegible]	74 25′	11	2.46	2.29	4.06	3.65	2.11	3.45	3.36	4.49	3 55	2.35	3.52	4.60
37 Peck's Beach, Cape May Co.	39 11′	74° 41′	20	3 54	3.99	4.13	7.17	1.72	2.66	2.21	3.79	6.26	1.24	4.01	4.86
38 Freehold, Monmouth Co.	40 1[illegible]′	74° 16′	190	3 07	2.77	5.51	3.82	2.34	3.00	4.82	5 56	3 62	2.71	4.01	3.98
39 Hightstown, Mercer Co.	40° 16′	74° 32′	100	1.58	4.91	5.77	2.73	2.91	......	......	......	......	0.90	5.38	......
40 Mount Holly, Burlington Co.	39° 5[illegible]′	74° 48′	30	1.34	3.60	2.69	2.73	2.29	3.25	3.49	7.11	3.69	1.55	3.93	3.07
41 Moorestown, Burlington Co.	39 58′	74° 57′	104	3.07	2.90	3.52	3.18	3.67	3.82	4.52	4.52	3.72	3.28	3.48	3.33
42 Haddonfield, Camden Co.	39 5[illegible]′	75° 02′	50	3.18	2.92	4.17	3.38	6.20	3.57	2.79	4.97	4 59	3.55	3.39	4.04
43 Atco, Camden Co.	39 46′	74° 54′	150	3.16	2.99	4.24	3.22	2.75	4.18	4.31	5.99	3.97	3.04	4.09	4.03
44 Vineland, Cumberland Co.	39° 29′	75° 01′	119	3.85	3.42	4 62	3.35	3.85	3.92	4.59	5.51	4.67	3.23	4.11	3.97
45 Burlington, Burlington Co.	40° 04′	74° 51′	60	3.26	3.57	3.49	3.83	5.86	5.04	3.51	5.31	3.47	3.36	2.86	4.32
46 Philadelphia, Philadelphia Co., Pa.	39° 56′	75° 10′	36	3.21	2.90	3.48	3.66	3.82	4.01	4.15	4.57	3.58	3.31	3.52	3.48
47 Salem, Salem Co.	39° 35′	75° 28′	15	4.51	......	......	......	2.11	5.27	5.76	......	......	......	......	1.84
48 Allowaystown, Salem Co.	39° 34′	75° 22′	[15]	3.61	3.52	2.65	2.43	2.97	3.27	2.76	8.98	3.36	3.73	3.93	4.00
49 Greenwich, Cumberland Co.	39° 21′	75° 20′	30	2.97	3.86	4.28	2.51	4.74	3.17	2.81	4.29	4.06	2.95	3.25	2.64
50 Dover, Kent Co., Delaware	39° 10′	75° 30′	40	2.91	3.15	4.94	2.99	2.82	3.24	5.04	4.95	4.39	2.78	3.98	3.01
51 Cape May, Cape May Co.	38° 56′	74° 58′	28	3.55	3.33	5.25	3.51	2.49	3.51	3.42	6.83	4.51	3.13	3.80	4.41
52 Fort McHenry and Baltimore, Md.	39° 16′	76° 35′	36	2.78	2.65	3.69	3.50	3.56	3.33	3.58	4.40	3.46	3.27	3.46	3.74

IN RAIN AND MELTED SNOW—Continued.

Depth in Inches and Fractions of Inches.—Continued.

	SEASONS.					SERIES.		Length.		OBSERVERS.
	Spring.	Summer.	Autumn.	Winter.	Year.	Beginning.	End.	Yrs.	Mos.	
27	10.70	12.39	10.52	10.21	43.82	July, 1843	Aug., 1860	17	2	L. H. Parsons.
28	10.83	15.01	11.71	8.95	47.55	Jan., 1866	Dec., 1880	15	...	E. R. Cook.
29	11.14	11.76	11.41	9.35	43.66	Oct., 1798	Dec., 1866	45	1	Ch. Pierce, E. Hance.
30	14.80	14.72	12.72	10.52	52.74	Jan., 1874	Dec., 1880	7	...	U. S. Signal Service Observer.
31	13.87	6.26	....	....	....	Jan., 1861	Aug., 1861	...	8	Prof. L. Harper.
32	8.16	9.20	9.63	9.64	36.63	June, 1831	May, 1832	1	...	From Smithsonian Coll.
33	15.53	15.65	16.12	11.03	58.33	Jan., 1874	June, 1876	2	6	U. S. Signal Service Observer.
34	16.08	14.35	16.54	10.62	57.59	Jan., 1874	Jan., 1876	2	1	U. S. Signal Service Observer.
35	12.38	12.95	12.79	11.68	49.80	Jan., 1874	Dec., 1880	7	...	U. S. Signal Service Observer.
36	9.82	11.30	9.42	9.35	39.89	Jan., 1874	Dec., 1880	7	...	U. S. Signal Service Observer.
37	13.02	8.66	11.51	12.39	45.58	Jan., 1874	Jan., 1876	2	1	U. S. Signal Service Observer.
38	11.67	13.38	10.34	9.82	45.21	Apr., 1874	Dec., 1880	6	9	Prof. Chas. F. Richardson.
39	11.31	....	....	....	....	Jan., 1876	Oct., 1876	...	7	Peddie Institute.
40	7.71	13.85	9.17	8.01	38.74	Sept., 1874	June, 1876	1	9	Dr. F. Ashhurst.
41	10.37	12.86	10.48	9.30	43.01	May, 1863	Dec., 1880	17	8	Thomas J. Beans.
42	13.75	11.33	11.53	10.09	46.70	Feb., 1864	Dec., 1870	6	6	J. S. Lippincott, S. Wood, J. Boadle.
43	10.21	14.48	11.10	10.18	45.97	Jan., 1872	Dec., 1880	8	8	H. A. Green.
44	11.82	14.02	12.01	11.24	49.09	Jan., 1866	Dec., 1880	15	...	Dr. J. Ingram.
45	13.18	13.86	9.69	11.15	47.88	July, 1856	Mar., 1868	5	10	Dr. E. R. Schmidt, Rev. A. Frost, T. C. Deacon.
46	10.96	12.73	10.41	9.59	43.69	Jan., 1825	Dec., 1880	56	...	Obs. Penn. Hospital, J. A. Kirkpatrick, U. S. S. O.
47	....	....	....	....	....	May, 1877	Jan., 1878	...	5	W. B. Matlock.
48	8.05	15.01	13.02	11.13	47.21	Jan., 1872	Nov., 1873	1	11	H. C. Perry.
49	11.53	10.27	10.26	9.47	41.53	Mar., 1864	Feb., 1873	9	...	Rebecca C. Sheppard.
50	10.75	13.23	11.15	9.07	44.20	July, 1870	Dec., 1880	9	8	J. H. Bateman.
51	11.25	13.26	11.44	11.29	47.24	Sept., 1871	Dec., 1880	9	4	U. S. Signal Service Observer.
52	10.75	11.81	10.19	9.17	41.42	May, 1836	Dec., 1880	44	8	Assistant Surgeon U. S. A., and U. S. S. Observer.

EXPLANATION OF TABLE OF RAIN AND MELTED SNOW.

The first column gives the names of localities or stations. Their more exact location is given in the columns of latitude and longitude.* The elevations are expressed in feet, above mean tide level, and are from the topographical maps of the Geological Survey, and from various railroad surveys. Where the height is estimated it is enclosed in brackets. They are believed to be closely approximate to the correct figures.

The amount of rain and melted snow is given in inches and hundredths, and the figures stand for the mean or average quantities for each month of the year. Following them are the mean quantities for the several seasons, and, lastly, that for the year. The dates of commencement and end of the record, and the length, are next given. The last column has the observers' names, or other authority for the records.

The mean quantities for the months are obtained by adding together the quantities for the given months in the several years observed, and dividing by the number of years. Inasmuch as there are often gaps—months without any record—allowance is made for them. Consequently the means at any given station may not represent any equal number of records for all the months of the year. The mean for any given month is the quotient of the total rainfall of that month throughout the period, divided by the number of months observed. The averages for the seasons are made by adding together the monthly averages belonging to the calendar months of the several seasons. Thus, spring covers the months of March, April and May. The annual fall is the sum of the months, or that of the four seasons.†

The length of the period includes the actual number of years (or twelve-months) and months observed, and is not, in many cases, coincident with the length of time between the dates of beginning and end, as they appear in the preceding columns. But in all the longer series there are no gaps. The records for short periods are of much less importance, and hence omissions in them of single months are of less account.

* The greater number of the latitudes and longitudes are taken from Charles A. Schott's tables, "Smithsonian Contributions to Knowledge," No. 222. The longitudes are west from Greenwich.

† Slight discrepancies between the sum of months or seasons and the year, in the case of two stations, are owing to differences in the yearly means as furnished by observers.

Wherever possible, the records which have been used in this table have been revised by the observers, and correspond with their figures, and the greater number have been thus revised, especially the longer records.

As referred to above, there is a probable error in the results reached in all of the shorter series. According to Schott's tables,* this amounts to 1.4 inches in a series 30 years long at New York; 0.6 inches in a 43-year series at Philadelphia, and in case of a single year to 12 per cent. Hence the difficulty in comparing places having short series of observations.†

An examination of the longer series shows that there is, in general, an increase in the mean quantity or depth for the year, in going from north to south and from northwest to southeast. The longer series give the following yearly depths:

West Point, N. Y	Average of	20	years	47.65	inches.
Lake Hopatcong	"	24	"	42.54	"
Fort Columbus, N. Y	"	24	"	43 24	"
Newark	"	37 8/12	"	46.21	"
New Brunswick	"	27	"	44.25	"
Lambertville	"	17	"	43.82	"
Morrisville, Pa	"	45	"	43.66	"
Moorestown	"	17 8/12	"	43.01	"
Philadelphia, Pa	"	56	"	43.69	"
Baltimore, Md	"	44 8/12	"	41.42	"

The average annual fall at Lake Hopatcong is 3.6 inches less than it is at Newark. It represents the Highlands fairly. And this difference corresponds with the decreasing quantity on going northwest into New York. Goshen, in the valley west of the Highlands, appears to have a considerably lower quantity—an average of 33.82 inches in eight years' observations. Easton's five-year record gives a mean of 45.56 inches. From the shape of the country it appears reasonable to believe that both of these records are not far from the correct means, and that there is a difference of at least seven inches between them in the year. But a further examination of the two by months shows that the difference is due to the relatively greater rainfall in the summer and autumn months. It would be expected that in the Highland valleys the larger rainfall would be in the warmer seasons, whereas in the broader Kittatinny valley the more uniform

*"Tables and Results of the Precipitation in Rain and Snow in the United States."—*Smithsonian Contributions to Knowledge, Washington*, 1872, *No.* 228, *p.* 144.

†The errors from gauges inaccurate and not properly located are evident in some of the discrepancies of the shorter series; but it is impossible to eliminate all of them. Some obviously incorrect records have been omitted.

surface, and possibly the more cleared area, would show a deficiency. The West Point record corresponds to that of Easton throughout the seasons. In the absence of careful observations at well-selected points, it is not possible to show by figures the influence of our mountains upon the rainfall. Their elevation and generally wooded slopes, as compared with the deep, low-lying and cultivated valleys, must tend to condense the moisture of passing clouds and thereby produce an increase in the mean quantity precipitated upon their crests above what falls upon the adjacent valleys or plains. And the variation is most likely to be greatest at the southwest and south, on the border near the Red Sandstone plain. As stated on a preceding page, the precipitation on the hills is frequently in the form of snow, when it is rain in the valleys. The depth of snow is known to be greater on the higher grounds than in the valleys. But we have no records of any measurements.

In the Red Sandstone plain the two long series of Newark and New Brunswick differ by very nearly two inches in the average for the year. New Germantown, near the Highlands border, agrees closely with that of New Brunswick. There appears to be a greater quantity at Newark in the winter and the early spring months. In this particular, Newark corresponds with all the stations on the eastern side of the State in their greater average rainfall. The Lambertville 17-year record agrees with that of New Brunswick very closely by seasons and by the year.*

And the general correspondence between New Brunswick, New Germantown and Lambertville yield a very fair average for the central and western part of this division of the State. The 44-inch line would include it all. The South Orange record corresponds closely with that of Newark in all the yearly divisions. Bloomfield (earlier than South Orange) shows a deficiency of 3.84 inches as compared with Newark. The rainfall at Jersey City, as obtained from a six-year series, also falls short of Newark by two inches in a year, confined, however, to the winter season only. It has been supposed, for several years, that at Paterson the rainfall was in excess of that of the more open plain country to the south and southeast. The record, as compared with that of Newark, appears to confirm this position. The observations at Paterson, for 1878,

*The rainfall at Lambertville, registered by Stephen B. Smith, for 1876........41.108
" " " " " " 1877........44.885
" " " " " " 1878........42.817
" " " " " " 1879........42.861
" " " " " " 1880........38.228

1879 and 1880, give a mean annual quantity of 47.07 inches, or 5.58 inches above the mean amount measured at Newark during the same period.* This excess is distributed through all the months excepting January and August, but it is greatest in March, May, June, July, October and November. Or, by seasons, the difference for spring is 1.92 inches; in summer, 1.94 inches, and in autumn, 2.10 inches.† A further comparison for the present year (1881) shows as great a variation from the Newark records.‡

The situation of Paterson, in the depression of the First mountain range, where the Passaic valley finds its outlet across these trap rock barriers to the open country, no doubt contributes to produce the greater rainfall.

Other localities, near these ranges, may possibly receive as much rain, but there are no records to show their existence.

The record at Trenton appears to be in excess of that at Morrisville, on the opposite side of the river, and also above those of Lambertville or New Brunswick. Here, also, the greater divergence is in the summer and autumn. The higher mean temperature of Trenton has been referred to on pages *24, *25. Whether the rainfall, also, is phenomenal and peculiar to the locality, or is the result of instrumental differences, it is impossible to determine. A longer series may cause it to disappear, or may develop a local difference.

In the Southern Interior region or division, the stations have comparatively short periods of observations. The longest are here tabulated by years,

Freehold	6	years,	9	months	45.21	inches.
Moorestown	17	"	8	"	43.01	"
Haddonfield	6	"	6	"	46.70	"
Atco	8	"	8	"	45.97	"
Vineland	15	"			49.09	"

giving an average of about 46 inches.

*The rainfall for 1881, at Paterson, was 68.11 inches; that of Newark, 39.03 inches.

†John T. Hilton, city surveyor, the observer at Paterson, says that the summer storms often appear to move from Paterson, northeastward along the southeast of the Highlands, to the Hudson at Peekskill. The excessive fall of March last was owing to several storms of this kind. And the fall at Peekskill for that month was great. At New York and Newark it was much less. It is quite probable that the saturated air as it moves northward is more suddenly cooled by the forest-covered Highlands, and its moisture is thrown down along the border land of the Red Sandstone plain adjacent to the Highlands.

‡From records furnished monthly by Mr. Hilton, the rainfall for Paterson in January, 1881, was 7.86 inches; February, 6.95 inches; March, 16.11 inches, the largest monthly quantity in all our records excepting that of August, 1843, at Newark, which amounted to 22.28 inches. Mr. Hilton says of March, "A large amount of the rainfall for the month was, no doubt, local, the remarkable storm of the 19th and 20th, in Paterson, resulting in a rainfall of 5.44 inches in about 11 hours, has no such record, either in New York or Newark. In New York the precipitation for the same storm was only 2.13 inches." In New Brunswick it was 1.39 inches In the six months, April to October, 1880, the total fall at Paterson was 30.40 inches; at Newark, the same months, amounted to 19.87 inches.

The long term of 56 years, at Philadelphia, yields a mean annual fall of 43.69 inches, which corresponds more nearly with that of Moorestown, the station having the longest record. The Vineland excess of over five inches, as compared with Moorestown (whose periods are most nearly alike), is distributed through all the seasons. It tallies closely with that of Atco in the summer and autumn. Vineland appears to get more rain all through the year than any of the other stations in this division. The agreement of Moorestown with the long series at Philadelphia is noteworthy. The limit of error in the latter is reduced to less than half an inch, hence it is an excellent standard for comparison.

The Greenwich series is the sole one in our Delaware Bay division. The limit of error in so short a period precludes any safety in generalizing upon it. Other things being equal, it would be supposed that the rainfall would be greater than further to the north. The Dover, Del., record gives an average of 44.20 inches, exceeding that of Greenwich by 2.7 inches. Comparing the seasons at the latter place with those of Philadelphia, the spring is wetter and the summer drier. And compared with Newark for same period, the Dover fall is 1.87 inches above that of the former place.

In the Atlantic coast belt we have the three U. S. Signal Service Stations, at Sandy Hook, Barnegat and Atlantic City. As the years included in the records are the same in each, 1874–1880, inclusive, the comparison is the more suggestive of local peculiarities. The mean annual rainfall at them is as follows:

Sandy Hook	52.74 inches.
Barnegat	49.80 "
Atlantic City	39.89 "

From the first two we should think that this shore belt had a greater rainfall. As compared with Freehold (1874–1880, excepting January, February and March, '74,) the year shows 7.5 inches more rain—a marked excess within so short a distance. The difference is not so much in winter as in the other seasons. It is 3.1 inches in the spring. Barnegat is nearly in the same latitude as Atco, and yet it receives nearly four inches more rain than the latter place does. The spring here also exhibits the greatest divergence. The rainfall at Atlantic City is phenomenal and unaccounted for at present. It is ten inches less than that of Barnegat, and 7.35 inches below that of Cape May. Compared with the record of the U. S. Signal Service, at Peck's Beach, which is only eleven miles distant and similarly situated, for the same *months and years, there is a difference of* 9.4 *inches—so much less at Atlantic City.* It is 3.8 inches less than that that of Philadelphia, and it is the least in our table. Possibly its situation, so far from the mainland and separated from it by tide marsh, instead of water, as is the case at Barnegat beach and also at Sandy Hook, the warmer land mass may not tend to the reduction of temperature and consequent fall of moisture like a body of colder salt water.

The Cape May average rainfall for 9 years and 4 months is 47.24 inches. Compared with Philadelphia, it is an excess of 3.55 inches, which is mostly distributed through the autumn and winter months.

The rainfall at the coast or beach stations, Sandy Hook and Barnegat, appears to be somewhat in excess of that in the interior. The Cape May record also shows an excess as compared with the interior stations generally, excepting Vineland. The curve for Cape May runs above that of Philadelphia, with few exceptions. The measurements seem to show that there are no months likely to have so little rain as corresponding dry months at Philadelphia. The table below gives the mean monthly rainfall at Newark, Moorestown, Vineland, Sandy Hook, Barnegat and Cape May for the years 1874–1880, inclusive.

TABLE.

STATIONS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Newark............	3.60	3.27	4.90	4.01	2.22	2.62	5.15	6.43	4.10	2.79	3.86	3.48	46.43
Moorestown.......	3.08	2.10	3.50	3.13	2.34	3.75	4.77	4.28	3.86	2.28	3.68	3.05	39.82
Vineland..........	3.91	3.00	4.93	3.63	2.55	4.12	4.76	5.83	4.62	2.43	4.00	4.38	48.16
Sandy Hook......	3.67	2.78	6.08	5.22	3.50	4.12	4.95	5.65	4.57	3.21	4.95	4.05	52.75
Barnegat..........	4.13	2.77	5.43	4.49	2.46	3.67	4.62	4.66	4.49	3.04	5.26	4.78	49.80
Cape May.........	3.17	2.77	5.36	3.81	2.51	4.07	3.81	6.65	4.62	2.60	3.69	5.16	48.22

We note in this table an excess in the monthly and annual fall at the coast stations above those of Newark and Moorestown; a close correspondence between Vineland and Cape May; a considerable excess at Sandy Hook above any of the other places, and an excess at the coast stations in March and September. This excess is probably owing to the presence of water to the west and southwest of each of the localities having a larger rainfall. And it is probable, also, that the mean annual fall is between two and six inches greater than it is northward and farther inland.*

In order to exhibit the variations between localities in both the rainfall by seasons and for the year, the diagram of Plate IV. was constructed. The stations are represented by vertical columns, placed side by side. They are drawn according to a scale, and the figures at the sides of the diagram express the depth in inches. The mean quantity or depth falling in the winter months (December, January and February) is represented by the lower section of the column, in black. The depths for spring are shown by diagonally-lined sections of the same, the summer by vertically-lined, and the autumn by horizontally-lined sections or lengths. The total height of the column represents, therefore, the successive rainfall for the four seasons, beginning with the winter. The variations in length of each section of the columns and in the total length, indicate corresponding differences in the amount of rainfall. Using the scale at the side, the quantities for seasons and year can be read off for each of the twenty-two places thus represented.

To show the annual fluctuation or distribution of rain among the months, the mean monthly values of twenty stations, each of whose periods exceed five years in length, were charted in five groups. The curves representing the several stations were assumed as types of their respective localities. The stations of the northern and central parts of the State all agree in a maximum rainfall in August, the curves reaching their highest point in that month. In nearly all of them were three depressions or minima, viz., the first in February, a second in May or June, and a third in October. A second but lower maximum was noted in the spring, in March and in May. The average of all corresponds somewhat with that expressing the annual fluctuation for the Atlantic coast, from Portland, Me., to Washington.† According to this more general curve, May and August are the wettest months ; then come November and December, while February, June, September and October are relatively drier. West Point,

*The greater rainfall of such sea beach localities is proved by the average of 81.87 inches at Cape Hatteras, and 80.96 at Cape Lookout, and 67.89 at Kitty Hawk, N. C.

†"Smithsonian Contributions to Knowledge," No. 288, p. 129.

PLATE IV.

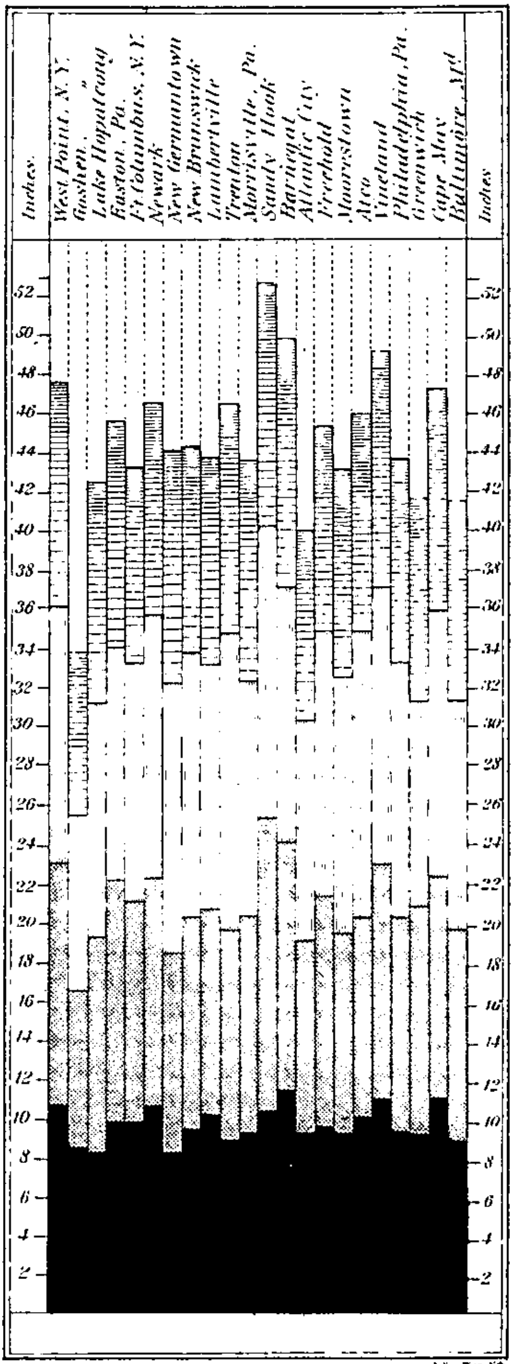


Diagram showing Rainfall by Seasons, and for the Year.

Winter. Spring. Summer. Autumn.

N. Y., Lake Hoptacong, Fort Columbus, Newark, New Brunswick, Lambertville and Trenton are expressed by this curve. Goshen shows exceptions in depressions for April and November. The stations of the Southern Interior and the Atlantic coast and Cape May *provinces* yield curves which vary somewhat from the above, in the spring maximum, coming two months earlier in the year, and the succeeding minimum is in May instead of June. The October minimum is also more pronounced. And in these respects the type for the southern part of the State approaches that for the Atlantic coast (Virginia to Florida). The wet months are, first, August, then March; and the drier months are May, second, October, and then February. The southern part of the State has its first dry period earlier in the year and the second is one month later. These correspond with the longer season at the South. Greenwich appears exceptional in having a wet May, but longer observations may remove this apparent exception.

The nature of the rainfall in the different seasons of the year varies somewhat. In the four warmer months of June to September, inclusive, the greater part of the total quantity of precipitation comes in the thunder storms. The number of rainy days is less than in the other seasons, although the average rainfall is greater. In the winter the storms are longer, lasting frequently from four to six days. The former or summer rains are often quite local, and confined to narrow belts, the latter sweep over all parts of the State. A low ridge or range of hills may divert the course of the summer shower, hence the greater variation in the summer rainfall. The more local rainfalls may be said to be limited to the spring and summer. The longer and more general storms advance across the State from southwest to northeast, and from west to east.*

The fall in any given storm has a wide range. It rarely exceeds

* Prof. Loomis, of Yale College, in his "Contributions to Meteorology," published in the *American Journal of Science*, Vol. XXI., pp. 1-8, has studied the courses or tracks of the storms which have been delineated upon the charts of the U. S. Signal Office since 1872, and which traversed the eastern part of our continent; and he has divided them into three classes: "I. Those whose course was for some days towards the west. II. Those whose course was towards some point between the south and east. III. Those whose course was towards some point between north and east" The dates of beginning and end, latitudes, longitudes, course and velocity in miles per hour are all tabulated. The storms of the II. and III. are the ones which cross our territory. Those of the second class occur more frequently during the colder months of the year. Their average velocity was 24 miles per hour. Their course is seldom maintained as far south as 30° N. latitude, after which it frequently changes to the northeast, so that they cross our territory as northeast storms also. Of the storms which cross the United States north of 38° nearly all pursue a course a little east of north, those coming from south of latitude 38° generally pursue a nearly northeast course. The storms of this class occur most frequently in autumn and least frequently in summer. The rate of movement of the storms in this class varied from 12.4 to 60.4 miles per hour, averaging 26.9 miles. At these rates such storms would move from Cape May or Delaware bay entirely across the State in two and a half to thirteen hours, or at the average rate, in about five hours. Or from Delaware bay to Sandy Hook the passage would be made in nearly four hours.

four inches in depth, and three inches is a heavy rain. In the Newark record the number of rains over three inches in thirty-seven years and eight months was thirty-six. Eight of them occurred in July; eight in August; five in October; three in November; two each in December and May; and one in each of the other months. These observations indicate the greater frequency of heavy rains in late summer and in autumn. Of special heavy rains, the storm of March 19th and 20th, 1881, at Paterson, is worthy of mention, when 5.44 inches fell in eleven hours. Another still heavier rainfall was that of March, 1875, at Parsippany, Morris county. F. A. Wilber (now of Rutgers College Faculty) kept a record at that time, and he measured seven inches of rain and melted snow coming in a single storm. The greatest freshet ever known in parts of eastern Monmouth county, July 11th, 1871, was caused by a shower which did not last more than three hours. The fall during the extraordinary shower between Trenton and Bordentown, on August 24th, 1877, was thought by Dr. C. C. Abbott to be about nine inches.* No doubt other equally great and sudden rainfalls could be included in this list if records were more generally kept.

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* Dr. C. C. Abbott, of Trenton, furnishes the following graphic account of this rain, written at the time, while every feature of it was still fresh in memory: "Previously to 1:30 P. M. the day offered no peculiar meteorological features. The temperature was 78° Fahrenheit at noon, wind southeast. About 1:30 P. M. the wind shifted to the southwest, and a heavy bank of blue-black clouds formed in the northwest. The appearance at this time was that of an ordinary summer shower. I did not notice any lightning or hear any distant thunder. While standing on the brow of the hill, near where my house stands, and facing the southwest, I noticed that a somewhat similar bank of cloud to that in the southwest was also rapidly forming, and the two appeared to be approaching each other, although not from opposite directions, of course. * * * * * * * * In a few moments there was a sudden change in the several conditions then obtaining. The stiff, northwest breeze suddenly ceased. A remarkable stillness pervaded the atmosphere and a feeling of oppression was very noticeable. * * * * * * * * Just at this time the two masses of clouds came in contact, apparently, (and really, I think,) directly over the extensive stretch of meadows lying north of Bordentown, along the Delaware river. At the moment of contact of these cloud masses there was a loud, humming sound, clearly audible, *but not caused by a wind, the leaves were motionless.* The two masses formed one, but retained their peculiar coloring, and in less than a minute, I should think, a huge water-spout formed—or, at least, the clouds became a single conical mass, with the apex downwards. As suddenly as it formed it broke, and, in ten minutes, at most, thereafter, the meadows were flooded. The storm now took the form of a general rain and extended over a considerable area. Such a rain, however, I never previously or since have witnessed. I found by experiment that it was impossible to breathe while facing it, unless by protecting my nose and mouth with my hand. At a distance of 100 feet objects were wholly obscured from view. This fearful rainfall continued for about forty minutes and then began to abate, but it was not until 5 P. M. that the rain ceased and the sky became comparatively clear. This storm was remarkable for one feature other than that of the quantity of water that fell, this was the absence of lightning.

"No ordinary means would have proved available for measuring the rainfall in this case. I have no doubt but that it was considerably in excess of what I ascertained at the time to be, we will say, the minimum, and here, certainly, in the immediate vicinity of the water-spout, was a rainfall of nine inches in the three hours of that day, from 2 until 5 P. M.

"Perhaps it may not be without interest to add that the storm caused a considerable destruction of life. Calves and sheep were drowned and many birds and small mammals were destroyed. I found numbers of drowned crows and some smaller birds immediately afterward, and some mice and squirrels. Insect life, also, was greatly affected by the storm, their ordinary means of shelter during showers proving quite inadequate to protect them against the violence of this remarkable rainfall.'

SNOW.

The *depth* of snow is not indicated in the above tables and statements of rainfall, since it is measured melted, as so much water or rain. The depth varies greatly from winter to winter, and in the same winter in different parts of the State. The quantity in the Highlands is much greater than it is in the extreme southern counties, and it lies for a much longer time, and later in the spring. We have no records of the depth in the more northern parts of the State. The measurements of Mr. Whitehead, at Newark, range between 6 feet 3 inches, in the winter of 1867–8, and 1 foot 2 inches, in that of 1877–8; and they give an average depth for thirty-seven winters of 40 inches. The average depth measured at Lambertville during the years 1839–1859, inclusive, was 29½ inches. It is probable that the average for the Highlands corresponds nearly with that of northern Pennsylvania, which is put at 60 inches for the winter season. The sleighing season continues for several weeks every winter in the Kittatinny valley and the Highlands. In the Red Sandstone plain it is shorter; and in the central and southern part of the State a winter may pass with only a few days of snow depth sufficient for sleighing.

The variation between localities is illustrated in the differences between Paterson and Freehold during the winter of 1880–1. At the former place, the total fall of snow was 48 inches; at the latter, it amounted to 77 inches, exceeding the greatest depth at Newark by 2 inches.

The snow melts much more rapidly near the coast than in the interior, and although the depth of fall may amount to nearly as much, sleighing is rarely possible beyond a few days at a time; and on the beaches, as at Atlantic City, sometimes for a single day only. And frequently the storms, which are accompanied with snow, end in rain. But the sea wind appears to have a very powerful effect in causing it to melt rapidly. The more sandy soil also helps to hasten its disappearance.

The snow is confined to the three winter months, and to November, March and April. The earlier and later appearances are so very rare and so slight, that they cannot be considered as features of our colder season. April snows are generally light and infrequent. But the remaining five months are generally marked by some snow in the Highlands, although the November falls often do little more than whiten the ground. In each of the remaining four it is to be expected.

The number of days on which rain or snow falls is not recorded by all observers; and we have figures from a few places only. Referring again to Mr. Whitehead's Newark table, the average number of *fair* days in 37 years was 215, of rainy days 95, of snowy days 28. By months the highest average of fair days is 20½ days, in June; the least 16, in November. (See Table of Climate of Newark, page *28.)

The greatest and least quantities of rain and melted snow by months at stations having long records, are presented in the table on opposite page. In the monthly columns the first gives the greatest, the second the least quantities measured at the several localities. A short table following this one gives the extreme annual rainfalls and the years in which they occurred.

TABLE OF EXTREME MONTHLY RAINFALLS, IN INCHES AND HUNDREDTHS.

	JANUARY.		FEBRU'RY.		MARCH.		APRIL.		MAY.		JUNE.		JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	Greatest.	Lowest.	Greatest.	Lowest.	Greatest.	Lowest.	Greatest.	Lowest.	Greatest.	Lowest.	Greatest.	Lowest.	Greatest.	Lowest.	Greatest.	Lowest.	Greatest.	Lowest.	Greatest.	Lowest.	Greatest.	Lowest.	Greatest.	Lowest.
Lake Hopatcong	5.15	0.48	5.84	0.40	7.54	0.40	7.35	0.25	7.69	1.89	7.64	0.93	7.91	0.90	10.70	0.50	11.44	0.35	9.82	1.04	8.46	1.61	7.30	0.60
Newark	6.52	0.64	6.07	0.82	10.00	0.98	11.36	0.39	8.74	0.85	9.74	1.04	8.94	1.12	22.48	0.95	11.03	0.55	7.73	0.32	8.74	0.87	7.54	0.92
New Brunswick	5.37	0.64	6.01	0.46	6.04	0.80	9.22	1.38	7.57	0.65	10.90	0.24	10.42	1.26	11.52	0.70	8.61	0.34	8.53	0.00	8.77	0.00	5.95	0.96
Moorestown	4.69	1.13	5.96	0.56	5.78	1.42	8.40	1.15	7.38	0.47	7.56	1.61	6.97	1.98	9.29	1.26	8.27	0.67	6.83	0.47	6.30	1.52	5.77	0.90
Vineland	6.30	1.30	6.25	1.73	6.84	1.22	8.32	1.73	8.45	0.77	5.59	0.60	9.82	1.85	10.64	1.28	9.91	0.69	6.75	1.08	7.24	1.49	7.52	1.88

NOTE.—The rainfall at Newark in August, 1881, was only 0.28 inches. The rainfall at New Brunswick in January was 7.85 inches, exceeding that of any January in previous years; in April the quantity was only 0.43, or less than any previous April observed; in July, none.

EXTREME ANNUAL RAINFALL.

	GREATEST.	YEAR.	LEAST.	YEAR.	LENGTH OF PERIOD.
Fort Columbus	65.51	1837	27.57	1836	24 years.
Lake Hopatcong	54.61	1850	30.06	1866	24 years.
Newark	57.05	1859	34.07	1856	37 years.
New Brunswick	59.95	1873	30.33	1876	27 years.
Lambertville	57.36	1841	32.32	1856	22 years.

From the foregoing table we see that the monthly extremes may range from *none* to 22.48 *inches*, also that the years vary from 30⅓ inches at New Brunswick, in 1876, to 59.95 inches at the same place in 1873. A longer period of observation would, no doubt, increase this range a very little.

DROUGHTS.

The periods of drought are indicated by the table of rainfall at Newark, 1843–1880, as it appeared in the annual report for 1880. While single months may occur with only a fraction of an inch of rain, such dry months are not likely to come together. And as an illustration of a severe drought, most extreme, observed at Newark, that of the present year (1881) is here given. The following account of it is taken from Mr. Whitehead's report for October, in the *Sentinel of Freedom:* "The year 1881 will ever be remembered for its remarkable drought. The fall of rain in July was 1.34 inches, the fall in August only 0.28, the fall in September 0.87, and the fall in October 2.23 inches, making a *total for four months of only* 5.22 *inches*. The least quantity *for the corresponding months of any year* since 1843, inclusive, was 10.08 inches, in 1848; the greatest, 34.28 inches, in 1843, (the quantity in August of that year, 22.485 inches, being unprecedented,) and the mean of the 38 years 17.028 inches."

Of this drought at Paterson, Mr. Hilton says: "The years 1880 and 1881 will be years not only noted for their remarkable drought, but as also having the apparent anomalous condition of recording aggregate rainfalls largely in excess of the mean yearly fall of half a century. The total rainfall for 1880 was 57.77 inches, an excess of 11.02 inches over the mean fall; the total rainfall for 1881 is 68.11 inches, an excess of 21.36 inches over the mean, and an amount of rain which no year since 1836 has a record equal to. * * * * * The drought of 1881, notwithstanding the heavy yearly and spring rainfalls, can be chiefly attributed to the unequal distribution of the rainfall and the very unfavorable periods in which the heavy rains occurred. The extraordinary rain of March, in Paterson, amounting to 16.11 inches, took place at a period when the ground was frozen solidly, and quickly disappeared through the water-courses, hardly moistening the surface of the earth; * * * * * the total rainfall for July, August, September and October amounting to only 7.83 inches, against a mean fall for these months of 16.38 inches. During these months there were ninety-eight days on which no rain whatever fell."

Referring to the water in the Passaic, Mr. Hilton says that on the 22d of October the water at the Arch street bridge was two inches lower than the extreme low water of October, 1879. This was probably lower than any previous record of its measurement.

The rainfall in the southern and on the western sides of the State was heavier than at the northeast, but the severity of the drought was distressing to farmers, and water was very low in the streams. The effect upon the Delaware river was noticed in the very low stage of the water. "In the fall of 1831, and before the feeder of the Delaware and Raritan canal was located, the water of the Delaware was lower than it had been for many years. Conrad White, at that time engineer of the canal company, requested Col. Simpson Torbert to make permanent recording marks along the river shore, which he did, assisted by Martin Coryell. One of these marks was made upon the New Jersey abutment of Centre bridge, on the lower or down-stream side, being twelve feet above the surface of the water at the bridge. Mr. George Van Camp, supervisor of the canal feeder, had levels taken in November, 1879, and also in September, 1881, to compare the elevations of low-water mark one with the other, and found them as follows:

1831	12	feet below mark.
1879	12.5*	" "
1881	13.215	" "

At Vineland, the rainfall of July, August and September amounted to 6.04 inches, while the average for sixteen years is 14.17 inches. "There were six days on which some rain fell in July, but only on the 30th and 31st did it produce a perceptible impression on vegetation; the amount, then, was 2.25 inches for all the rest of the month, 0.71 inches only on the 7th, 13th, 16th and 27th. During August, rain fell on the 2d, 7th, 8th and 13th (total, 0.73 inches.) From the 13th to 3d of September, an interval of twenty-one days, there was no rain, and the average temperature was 76.18°, and on all but two of these days the temperature was above 80°, and on several of them it was over 90°. From September 12th to October

* Lambertville paper, from Martin Coryell.

5th, twenty-two days without rain, with an average temperature of 77°. These conditions told fearfully on all crops." *

Inspecting the Newark table we find that extremely dry seasons are not generally consecutive. But the same season may run below the average for two or three years in succession. Thus the autumns of 1878, '79, '80 and '81 have all been drier than the average. On the contrary, the summer rainfall for these years have exceeded the average. The yearly quantities show dry and wet years alternating irregularly with few exceptions. The years 1854, '55 and '56 were all below the average, and the deficiency in those years was nearly 17 inches. The total fall of 1848 and '49 amounted to 76.83 inches, or a deficiency of 15.59 inches. In the New Brunswick record the rainfall for the past six years has been less than the average by about 9 inches; and 1879, '80 and '81 give an average of only about 34 inches.

The total rainfall at New Brunswick during the drought of the past summer and autumn was 2.94 inches in 123 days—from July 1st to November. In 1856 the rainfall for the six months, February to July, inclusive, was 14.55 inches. The following table of *droughts* or *dry periods*, kept by W. H. Talcott, C. E., at Lake Hopatcong, was furnished by the Morris Canal Company:

TABLE

Of Droughts shown by Records kept at Lake Hopatcong, Jan., 1846, to Dec., 1869.

YEAR.	FIRST DAY.	LAST DAY.	LENGTH.	RAINFALL IN TIME.
1847	Mar. 27.	May 30.	65 days.	1.53 inches.
1848	" 12.	" 2.	52 "	1.95 "
"	July 4.	Sept. 13.	72 "	1.84 "
1849	Dec. 31, ('48.)	Mar. 20.	80 "	2.37 "
"	May 31.	July 20.	51 "	1.57 "
1851	July 25.	Oct. 29.	98 "	4.79 "
1855	Jan. 29.	Mar. 16.	47 "	0.65 "
1856	" 6.	Apr. 19.	105 "	2.66 "
"	June 19.	Aug. 3.	47 "	0.95 "
"	Sept. 29.	Nov. 21.	53 "	1.70 "
1858	Feb. 21.	Apr. 8.	47 "	0.40 "
1864	Dec. 30, ('63.)	Mar. 1.	63 "	1.44 "
1867	Aug. 29.	Nov. 30.	92 "	5.01 "
1868	Nov. 30, ('67.)	Apr. 4.	127 "	4.49 "

The most severe and long sustained droughts in this record were those of 1856, 105 days, with but 2.66 inches of rain, and those of

* Letter from Dr. John Ingram, Meteorological Observer at Vineland.

1867 and 1868, which together make a total length of 219 days, equivalent to seven months, extending over the cold half of the year, and receiving but 9½ inches of rain.

BAROMETRIC PRESSURE. WEIGHT OF THE ATMOSPHERE.

No attempt has been made to collect the records of barometric observations. The diurnal, annual and secular movements are so slight as not to be taken into account in this connection, and their discussion belongs to the department of physics rather than to a popular notice of climate. The variation between localities, due to differences of elevation, are according to a general law, and the amount of this variation does not exceed two inches in our State. The barometer falls as the height increases. The rate varies a little according to temperatures, but at ordinary summer heat, say 72°, the fall is one-tenth of an inch for 95 feet rise; at 32°, a fall of a tenth corresponds to 87 feet; but, in round numbers, the difference is about one inch for 900 feet rise. Hence, on our highest ridges the difference would be about two inches, and throughout our Highlands the depression would range from 1 to 1.5 inches. In recording barometric observations, corrections are generally made so as to reduce them to a common datum, which is that of the ocean level.

The most important barometric observations are those made during the passage of low pressures or storm centers across our territory. These centers of low pressures or *cyclones* are in nearly all cases accompanied by either rain or snow, while the high pressures or *barometers* are marked by clear weather and dry air. The greater the divergence from the mean at any locality, the more severe the changes in the weather generally. And very low depressions are apt to be accompanied by high winds, since the indraught of air is stronger to restore the equilibrium. The winds in the passage of the low pressures move around from south to east, &c., whereas in high barometers this order is reversed. According to Buys-Ballot's Law of the Winds, "stand with your back to the wind, and the lowest barometer or center of depression will be to your left in the northern hemisphere." While the low barometers are marked by moisture (and a rise of temperature in the winter season), the high areas or *anti-cyclones* are accompanied by extremes of temperature—in the summer by heat and in the winter by great cold.

The U. S. Signal Office publishes daily maps on which are charted the tracks of these areas of low and high pressures, (the localities of equal pressure being connected by lines which are known as isobars.) From the position of these centers of pressure the indications are made out. The State is so small that they traverse its territory in a few hours at most, and consequently any system of signals must be part of the general weather service of our country, to be effective or valuable in announcing the coming of changes.

The differences between the mean barometric measurements in the several parts of the State, excepting as modified by altitude, which has been referred to above, are too inconsiderable to affect us sensibly, and scarcely enter into the subject of our climatology. Careful observations, and long continued, may prove the existence of differences, and they may be found to affect the human organism; and the study of the sanitary relations of climate must include them.

SANITARY RELATIONS.

The climate of New Jersey, as a whole, is salubrious. It is more equable than that of the same parallels further west. And yet it is not the equability accompanied by great moisture and dampness, or cold, which may make an even temperature undesirable and unhealthy. Our extremes of temperature, or the range, are not so great as in the northern part of New York and New England generally. The lowest temperatures of our winters are not so low by 10° to 20° as in these States to the north. And diseases of the respiratory organs are neither so prevalent nor so acute and fatal. Persons from New England and New York find the climate of the southern part of the State more comfortable and beneficial in the case of any predisposition to lung diseases. Vineland and Atlantic City have become winter resorts for this class of patients, who escape the rigors of a more northern climate. For evenness of temperature, Cape May has already been indicated as a remarkable locality, and the advantages of so equable a climate within our borders deserve the attention of all interested in the study of medical geography, or in exemption from the extreme cold and sudden changes of our winters. In general, our seaside is so accessible, and so well provided with comfortable and luxurious accommodations, that many prefer to go there rather than further south, and find it quite as beneficial. The growth and prosperity of Atlantic City is largely owing to its winter homes and its patronage throughout the year. These seaside towns are so easily and quickly reached that they are becoming the homes for many invalids and delicate people, who cannot live further inland, where the extremes of both heat and cold are more intense and trying.

On the other hand, our climate is not like that of the Southwest and South Atlantic Coast States in the heavier summer rainfall and prolonged heat periods. Our heated terms are shorter, and the nights are cooler, than at the South, and, consequently, they are not so enervating or exhausting. We have less malarial fevers, so prevalent and fatal along the more southern Atlantic coast and in the Gulf States. Our seaside offers the escape from the extremes of heat also, and it is thronged during the whole summer by a large population seeking comfort and health.

Taking the year through, our situation is favorable so far as climate is concerned, and the records of longevity are evidence of the general healthfulness of our State.

The diversities of climate within the limits of the State must have their effect, and the general healthfulness is modified more or less by these varying conditions. The equable character of the coast and its sanitary advantages have been mentioned above. In the northern part of the State the Highlands offer many locations where the air is very bracing and dry, and where there are no swampy tracts or wet lands to give rise to any dampness or malarious exhalations. It would be beyond the scope of this article to mention localities. The general statements of the preceding pages indicate the districts.

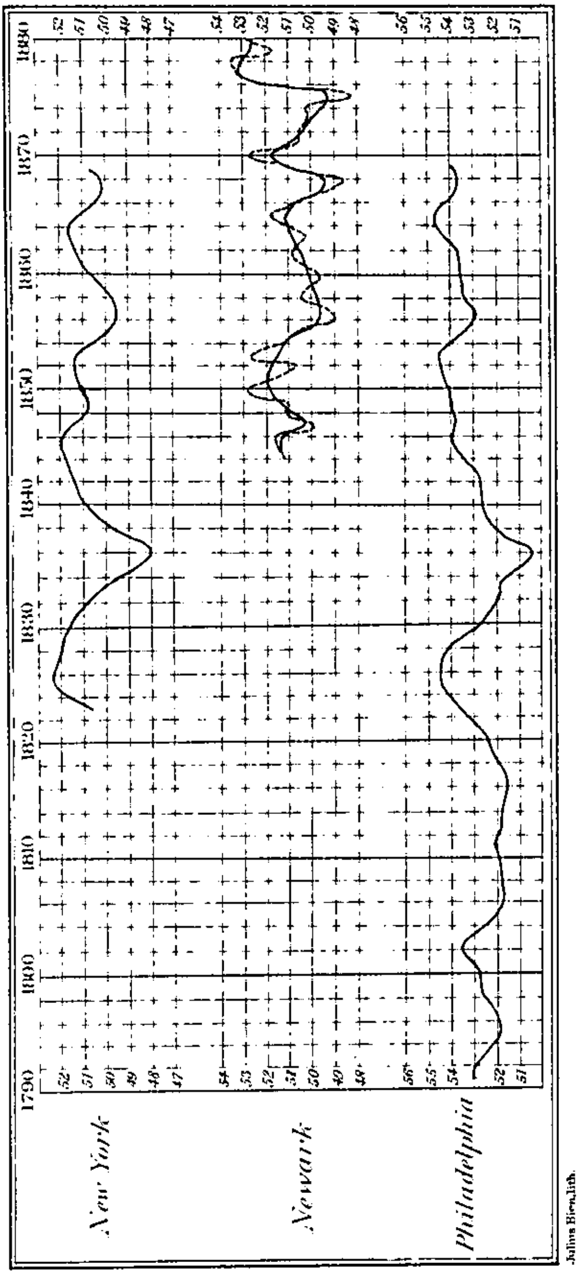
In the Southern Interior, the dry, sandy soil, and the extensive pine forests, appear to conduce to healthfulness, and a few localities were noted long ago as *sanitariums* for persons with weak lungs.

In conclusion it may be said that the study of climate in its sanitary relations is still in its infancy. This is largely due to the absence of accurate meteorological data and a general ignorance of the peculiarities of our climate. The study of disease and of climatological conditions must go together. The claims of a suffering humanity call for all the aid which science can give. And it may result that in our own borders there are many of the peculiar conditions and local features which can be used with effect not only in prolonging life, but also in restoring health, quite as well as the famous resorts of the South or far West. The field is an inviting one, and encouraging of success.

PERMANENCY OF CLIMATE.

There is a prevalent impression that the climates of the globe have undergone material changes within the historic period, or since records of observations on temperature and rainfall have been kept; and that changes are still in progress. It is generally believed that in our country the alternations of temperature are more sudden and the extremes greater; that the springs are earlier and the seasons, in general, more variable; that the rainfall is less and more unequally distributed through the year, and, consequently, that the river floods are higher and the variations in springs and streams more irregular than formerly. In Europe, the changes in climate have been thoroughly discussed by Humboldt, Dove, Glaisher, and other eminent meteorologists. Both the fluctuations in temperature and those of rainfall have been investigated. The results do not indicate any changes, or any regular variations, or cycles of definite length, although there are found to be comparatively short rainfall periods, which correspond somewhat with observed sun-spot periods. It is doubtful if even these shall prove coincident throughout when tested by longer series of observations. The fluctuations of temperature do not appear capable of resolution into any orderly arrangement. Warm and cold terms of years, of varying lengths, alternate irregularly. The weather records of our country do not go back so far as some of the European series, but they also exhibit the same apparent irregularity in the sequence of warm and cold years and a lack of any periodicity in the annual rainfall. Our temperature records are mostly confined to the present century. Those of New Haven date from 1780; those of Philadelphia from 1758 (with some gaps in the 18th century); those of New York from 1821. In the investigation of the secular variation in temperature, the annual means for the stations having long records, have been plotted, and their curves presented in plate facing page 310 of Schott's Tables of Atmospheric Temperature. Two of the curves, those for Philadelphia

PLATE V.



Curves of Secular Change in the Mean Annual Temperature.

and New York, are reproduced in our Plate V., and with them that of Newark for its term (1843–1880). The general curve and also the yearly irregularities or departures from it are shown, the former by a continuous, the latter by a broken line. The vertical lines represent two-year periods, and the decades are indicated by figures at the top, beginning with 1790. The horizontal lines are for temperatures, the figures for which are at the sides of the diagram. They stand for *mean* annual temperature. We note a depression about 1794, in the Philadelphia curve, then a rise to a maximum in 1802. From that year to 1816 there was a general decline. Thence, onward, for ten years, the mean temperature increased quite rapidly, and here the New York curve begins; both then as rapidly fall, and reach a very decided minimum in 1836. From that depression the Philadelphia curve rises irregularly to a maximum about 1853. Both cities show a depression about 1856–7; and the same appears in that of Newark, also. From that forward the undulations, as shown in Newark, are shorter, and there are notable depressions for the years 1867–8, and again in 1875. The rise thence to 1877–80 is also remarkable. The cold epochs were therefore 1794, 1816, 1836, 1856–7, 1867–8, and 1875, or at intervals of about 22, 20, 21, 11 and 7 years. But the subject of change of climate is best stated in Schott's conclusion: "There is nothing in these curves to countenance the idea of any permanent change in the climate having taken place or being about to take place; in the last 90 years of thermometric records, the mean temperatures showing no indication whatever of a sustained rise or fall. The same conclusion was reached in the discussion of the secular change in the rainfall, which appears also to have remained permanent in amount as well as in annual distribution."*

To exhibit the seasonal variations in temperature, and to represent graphically the valuable record of Mr. Whitehead at Newark, the diagrams of Plate VI. were constructed. The vertical lines represent the years observed. The seasons and the year are each represented by irregular lines running from left to right lengthwise the page. The mean temperatures for each are indicated by broken horizontal lines. The figures at the *bottom* of the page express the temperature in degrees. Examining any one of these lines—for example, that of the winter—we see by rises the warmer and by

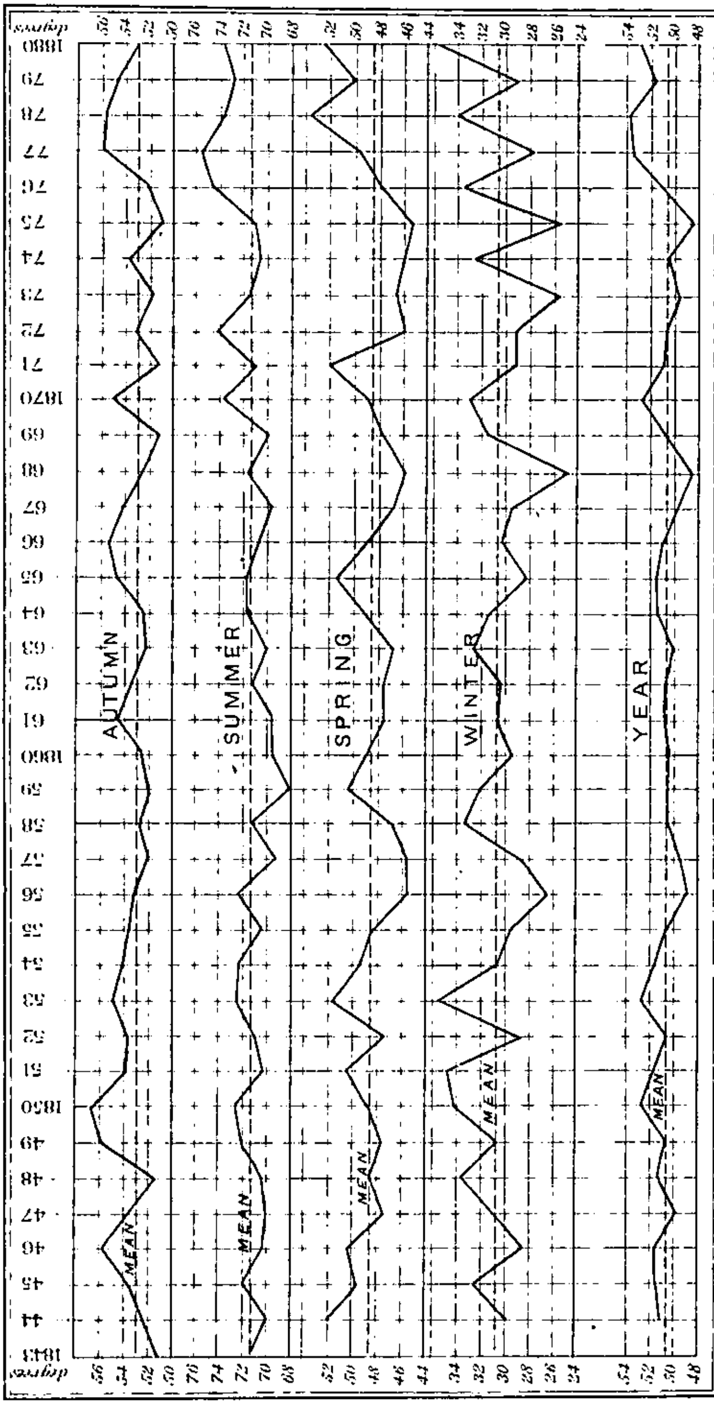
*"Tables of Atmospheric Temperature: Smithsonian Contributions to Knowledge," No. 277, p. 311. Washington, 1876.

depressions the colder seasons in the consecutive years covered by the record. The lines, as compared with one another, exhibit (by its greater irregularity) the greater alternations in the winter; the more even summers; and the general parallelism between the winters and springs, and between the summers and the autumns; also a slight degree of correspondence throughout. In other words, like winters are generally followed by like springs, and so, too, *like summer, like autumn.*

Going back quite as far as any of our temperature observations, are the records of seasons of navigation and ice in rivers and harbors. One of the best is that of the season of navigation in the Hudson river. The dates of opening and closing of the river at Albany, N. Y., indicate the severity of the winter, by the longer periods, or the mildness, by the shorter time, between the closing by ice in fall or winter, and the spring date when the river was again free from ice.* The table below is taken from Part I., Vol. 2, of the "Results of Meteorological Observations of the U. S. Patent Office and the Smithsonian Institution," Washington, 1864, and the Legislative Manual of New York for 1881.

* Although Albany is 100 miles north of our boundary on the north, the condition of the ice in the Hudson marks our winters—of northern New Jersey—quite as well as any other record which we could have, and hence it is here inserted as applicable to our State.

PLATE VI.



Julius Bien, lith.

Diagram showing Fluctuations in Mean Temperature for the Year and the Seasons, at Newark.
Period, 1843 to 1880.

DATES OF OPENING AND CLOSING OF THE HUDSON RIVER AT ALBANY, AND THE NUMBER OF DAYS OF NAVIGATION.

[From the reports of the Regents of the University, and other sources.]

SEASONS.	RIVER FREE FROM ICE.	RIVER CLOSED BY ICE.	NO. OF DAYS OPEN.
1646		November 25th	
1675–6	February 26th		
1786	March 23d		
1789		February 3d, (1790)	
1790	March 27th	December 8th.	256
1791	March 17th	December 8th	266
1792		December 12th	
1793	March 6th	December 26th	295
1794	March 17th	January 12th, (1795)	301
1795		January 23d, (1796)	
1796		November 28th	
1797		November 26th	
1798		November 23d	
1799		January 6th, (1800)	
1800		January 3d, (1801)	
1801	February 28th	February 3d, (1802)	340
1802		December 16th	
1803		January 12th, (1804)	
1804	April 6th	December 13th	251
1805		January 9th, (1806)	
1806	February 20th	December 11th	294
1807	April 8th.	January 4th, (1808)	271
1808	March 10th	December 9th	274
1809		January 19th, (1810)	
1810		December 14th	
1811		December 20th	
1812		December 21st	
1813	March 12th	December 22d	285
1814		December 10th	
1815		December 2d	
1816		December 16th	
1817		December 7th	
1818	March 25th	December 14th	264
1819	April 3d	December 13th	254
1820	March 25th	November 13th	233
1821	March 15th	December 13th	273
1822	March 15th	December 24th	284
1823	March 24th	December 16th	267
1824	March 3d	January 5th, (1825)	308
1825	March 6th	December 13th	282
1826	February 26th	December 24th	301
1827	March 20th	December 25th	280
1828	February 8th	December 23d	319
1829	April 1st	January 11th, (1830)	285
1830	March 15th	December 23d	283
1831	March 15th	December 5th	265
1832	March 25th	December 21st	271
1833	March 21st	December 13th	267

DATES OF OPENING AND CLOSING OF THE HUDSON RIVER AT ALBANY, AND THE NUMBER OF DAYS OF NAVIGATION—*Continued.*

[From the reports of the Regents of the University, and other sources]

SEASONS.	RIVER FREE FROM ICE.	RIVER CLOSED BY ICE.	NO. OF DAYS OPEN.
1834	February 21st	December 15th	297
1835	March 25th	November 30th	250
1836	April 4th	December 7th	247
1837	March 28th	December 13th	260
1838	March 19th	November 25th	251
1839	March 21st	December 18th	272
1840	February 21st	December 5th	288
1841	March 24th	December 19th	270
1842	February 4th	November 29th	298
1843	April 13th	December 9th	240
1844	March 14th	December 11th	272
1845	February 24th	December 4th	283
1846	March 15th	December 15th	275
1847	April 6th	December 24th	262
1848	March 22d	December 27th	280
1849	March 19th	December 25th	281
1850	March 9th	December 17th	283
1851	February 25th	December 13th	291
1852	March 28th	December 22d	269
1853	March 21st	December 21st	275
1854	March 17th	December 8th	266
1855	March 20th	December 20th	275
1856	April 10th	December 16th	250
1857	February 27th,	December 27th	303
1858	March 20th	December 18th	273
1859	March 13th	December 10th	272
1860	March 6th	December 14th	283
1861	March 5th	December 23d	293
1862	April 4th	December 19th	259
1863	April 3d	December 11th	252
1864	March 11th	December 12th	276
1865	March 22d	December 16th	269
1866	March 20th	December 15th	270
1867	March 26th	December 8th	257
1868	March 24th	December 5th	256
1869	April 5th	December 9th	248
1870	March 31st	December 17th	261
1871	March 12th	November 29th	262
1872	April 7th	December 9th	246
1873	April 16th	November 22d	220
1874	March 19th	December 12th	268
1875	April 13th	November 29th	230
1876	April 1st	December 2d	245
1877	March 30th	December 31st	276
1878	March 14th	December 20th	281
1879	April 4th	December 20th	260
1880	March 5th	November 25th	265

NOTES.

1639.—Heavy flood at Albany.

1617.—Disastrous flood in the Spring.

1740-41. }
1765-66. } River closed as far down as Paulus Hook, now Jersey City.
1779-80. }

1817-18.—Winter long and intensely cold. The ice moved March 3d, but soon became fixed. River remained closed 108 days.

1820.—River closed November 13th; opened on the 20th, and finally closed on 1st of December. River closed this winter to New York bay.

1824.—River clear of ice January 11th, and remained thus several days.

1827-28.—River opened and closed repeatedly at Albany during this winter. It closed the second time December 21st.

1830-31.—Opened by heavy rains, but closed again January 10th.

1832-33.—River opened January 3d, and closed again January 11th.

1834-35.—River opened at Albany, March 17th. A steamer came up as far as Van Wie's Point (5 miles below Albany), on the 18th.

1847-48.—River closed December 24th, and opened on the 31st.

1856—Closed at Fort Washington, December 19th, for 12 days.

1857.—February 9th.—The ice broke up in the Hudson, at Albany, early in the morning, and formed a dam a few miles below, overflowing the lower part of the city to an extent never before known. The water rose about 20 feet above mean summer level, and there remained several days. Steamers arrived from New York on the last day of February, but navigation was subsequently interrupted several days by ice.

1858-59.—River frozen at Fishkill Landing, January 1st, so that people crossed on foot. Broke up February 21st. Stopped 7 weeks, 3 days. Only 1 week good crossing with teams.

None of our records indicate any diminution in rainfall in the mean quantity for year or seasons, nor does there appear to be an increased number of dry periods. In severity the drought of 1881 was certainly extreme. From the clearing away of forests, particularly in the Red Sandstone plain, and the general cultivation of the soil, drainage of wet tracts, &c., it is reasonable to suppose that the rainfall might be slightly diminished in quantity, judging by the well-known comparative observations on rainfall in forests and in cleared areas, in Germany, France and Switzerland. But our records do not show any such desiccation in the climate, nor will measurements, as usually made, exhibit the probable changes. The distribution of the rains through the months and seasons is probably less uniform since the settlement and clearing of the country. That is they are more irregular, and heavy rainfalls are probably more common. Of course the rains run away more quickly, and that our streams, especially the larger rivers and creeks, are more subject to very high freshets, appears to be generally conceded, and reasonably so, since there is a vastly diminished area of swamp and woodland to retain in the surface the rains, and to allow their more gentle flowing away. The drying up of springs, supposed to be lasting, and of streams which formerly carried water even in very dry seasons, are evidences of the greater *desiccation* of the soil at times, if not of the climate. (See Marsh's "Earth as Modified by Human Action.")

The rainfall at Newark, for the seasons, from the summer of 1843 to the winter of 1880–81, is exhibited in the diagram of Plate VII.

The series is in five-year groups, placed one below the other, so that the seasons occupy the same relative position throughout. Thus, following any given vertical line from the top of the diagram down, the winters, springs, summers or autumns (as the case may be) of the successive groups are seen. The years are separated by the heavy, black, vertical lines which run between the autumn and the winter. This division by seasons does not quite coincide with the calendar year, as the winter is placed first, and December is thereby transferred to the succeeding year. The winter of 1843–44, for example, appears in 1844. This division was thought to be preferable for most purposes of study of such a diagram, to that in which the year closes with winter. The datum lines throughout are at 5 inches. The 10-inch, 15-inch and 20-inch lines are made heavier than the intermediate lines representing depth. Beginning with the summer of 1843, it is, therefore, easy to follow the line through the series, and, by the rising and falling, *read down the page* the greater and less depth for each season, to the end, in Autumn of 1880. By this graphic representation, the character of *consecutive seasons* is better exhibited. For example, the dry seasons of 1848 and 1849 appear, and seven consecutive seasons are here below the average. The greater fall of 1859, and that of 1868, 1869 and 1870, also appear prominent. Beginning with the spring of 1868, there are ten consecutive wet seasons, only one of which is below the mean, and that about an inch. The two driest seasons together are autumn of 1867 and the following winter, having a total fall of 14.7 inches. By the sharp rises and sudden falls in the line, it appears that *extraordinarily wet* seasons do not come together (in this record). But nothing in the irregularities of the line indicates any permanent

PLATE VII.

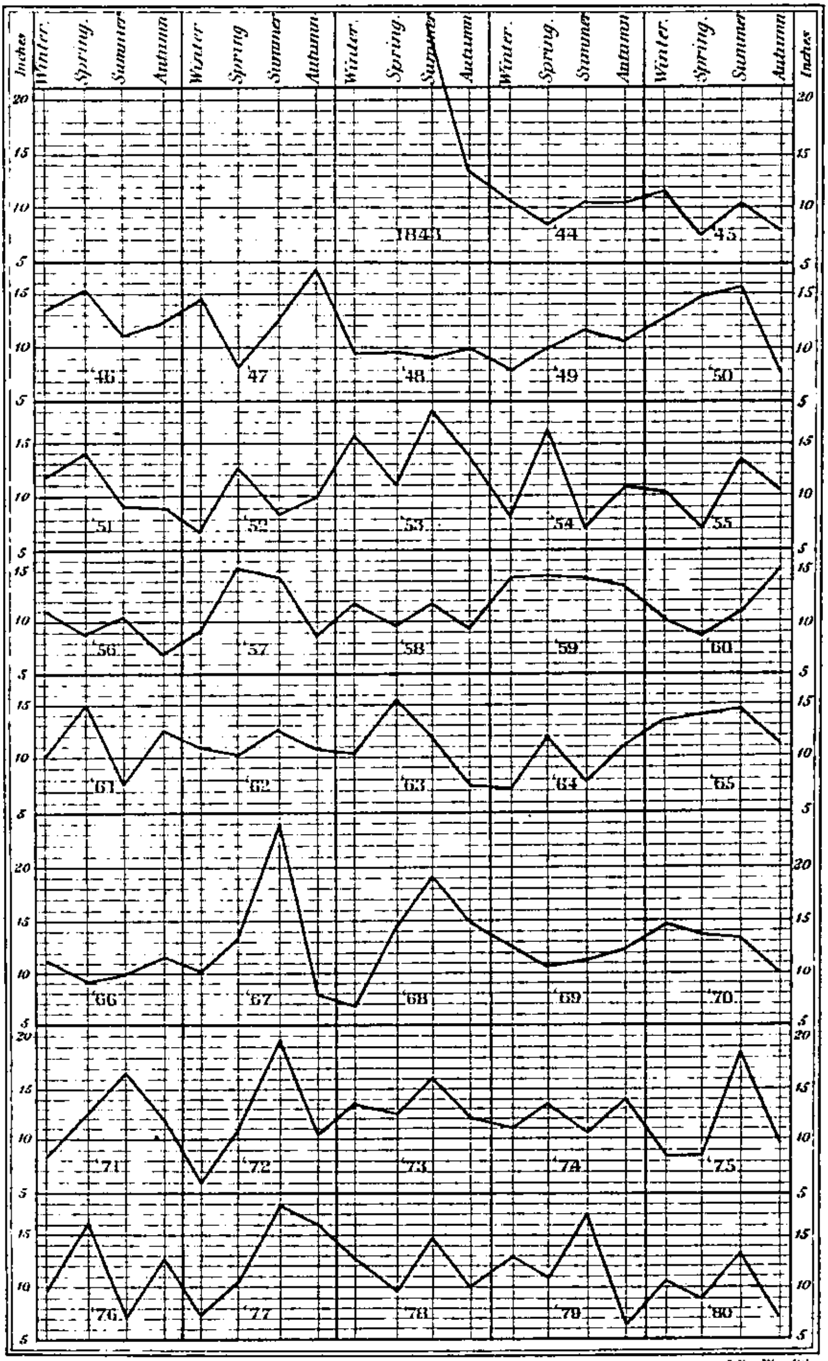


Diagram showing Rainfall for the Seasons, at Newark, 1843-1880.

change in the average seasonal quantities, nor any definite periods of wet or dry seasons or years.

Taking the annual curve of the Newark rainfall, we note a dry period of thirteen years, (1854–1866, inclusive,) having an average fall of 44.58 inches, and a wet period of twelve years, (1867–1878, inclusive,) with an average of 50.09 inches. But the yearly curve also fails to show any signs of periodicity.

In conclusion, the only characteristic features discernible are: that from 1843 to 1856 was a period of seasonal extremes; from 1857, onward through 1866, the distribution was more uniform; and, lastly, since 1866 the extremes are again more pronounced.

HISTORICAL NOTES OF CLIMATE AND WEATHER PHENOMENA.

The earliest printed notice of the climate of New Jersey is in "A description of the province of New Albion, &c., published in 1648." The following extract from it is here given: "Whereas that part of America, or North Virginia, lying about 39 degrees on Delaware bay, called the province of New Albion, is situate in the best and same temper as Italy, between too cold Germany, and too hot Barbary; so this lying just midway between New England 200 miles and Virginia 150 miles south, where now are settled 8,000 English, and 140 ships in trade, is freed from the extreme cold and barrenesse of the one, and heat and aguish marshes of the other, and is like Lumbardy, and a rich fat soil, plain, and having 34 rivers on the mainland, 17 great Isles, and partaketh of the healthiest aire and most excellent commodities of Europe, and replenished with the goodliest woods of oaks and all timber for ships and masts, mulberries, sweet cypresse, cedars, pines and firres, 4 sorts of grapes for wine, and raisins, and with the greatest varity of choice fruits, fish and fowl, stored with all sorts of corn, yeelding 5, 7 and 10 quarters an acre."*

From the account of Thomas Rudyard, deputy governor of East Jersey, written in 1683, we extract the following paragraph descrip-

*That the name New Albion was then applied to New Jersey appears in a letter of Robert Evelin, which was included in the same pamphlet. We extract: "But nevertheless to satisfie you of the truth, I thought good to write unto you my knowledge, and first to describe you from the north side of Delaware unto Hudson's river in sir Edmunds' patent, called New Albion, which lieth just between New England and Maryland, and that ocean sea, I take it to be about 160 miles."—*Smith's History of New Jersey*, pp. 27-28.

tive of that province: "As for the temperature of the air, it is wonderfully situated to the humors of mankind; the wind and weather rarely holding one point, or one kind, for ten days together; it is a rare thing for a vessel to be wind-bound for a week together, the wind seldom holding in a point more than 48 hours; and in a short time we have wet and dry, warm and cold weather." This description is as pertinent to-day as it could have been in 1683.

In Thomas Budd's "Good Order Established in Pennsylvania and New Jersey in America," printed in 1685, there is the following: "The dayes in the winter are about two hours longer, and in the summer two hours shorter than in *England*; the summer somewhat hotter, which causeth the fruits and corn somewhat to ripen faster than in *England*, and the harvest for Wheat, Rye and Barley, being about the latter end of *June*. In the winter season it is cold and freezing weather, and sometimes Snow, but commonly very clear and Sun-shine, which soon dissolves it."

Peter Kalm, a celebrated Swedish traveler and natural philosopher, who spent the winter of 1748–9 in West Jersey, and afterwards, in 1750, traveled through the State, writes as follows of the snow at Penn's Neck, February 23d, 1749: "Snow lay yet in several parts of the woods, especially where the trees stood very thick, and the sun could not make its way; however, it was not above four inches deep. All along the roads was ice, especially in the woods, and therefore it was very difficult to ride horses which were not sharp-shoed. The people who are settled here know little of sledges, but ride on horseback to church in winter, though the snow is sometimes near a foot deep. It lays seldom above a week before it melts, and then some fresh snow falls."*

While residing at *Raccoon*, a locality in Gloucester county, this traveler collected notes about the effects of severe cold upon trees and of late frosts in spring in killing blossoms and leaves. We extract the following:

"I often inquired among the old *Englishmen* and *Swedes* whether they had found that any trees were killed in very severe winters, or had received much hurt. I was answered that young hickory trees are commonly killed in very cold weather, and the young black oaks likewise suffer in the same manner. Nay, sometimes black oaks five inches in diameter were killed by the frost in a severe winter, and sometimes, though very seldom, a single mulberry tree was killed.

*"Travels into North America," by Peter Kalm, London, 1771, Vol. II., p. 73.

Peach trees very frequently die in a cold winter, and often all the peach trees in a whole district are killed by a severe frost. It has been found repeatedly, with regard to these trees, that they can stand the frost much better on hills than in valleys; insomuch that when the trees in a valley were killed by frost, those on a hill were not hurt at all. They assured me that they had never observed that the black walnut tree, the sassafras, and other trees, had been hurt in winter. In regard to a frost in spring they had observed at different times that a cold night or two happened often after the trees were furnished with pretty large leaves, and that by this most of the leaves were killed. But the leaves thus killed have always been supplied by fresh ones. It is remarkable that in such cold nights the frost acts chiefly upon the more delicate trees, and in such a manner that all the leaves, to the height of seven and even of ten feet from the ground, were killed by the frost, and all the top remained unhurt. Several old *Swedes* and *Englishmen* assured me they had made this observation, and the attentive engineer, Mr. Lewis Evans, has shown it me among his notes. Such a cold night happened here in the year 1746, in the night between the 14th and 15th of *June*, new style, attended with the same effect as appears from Mr. *Evans*' observations. The trees which were then in blossom, had lost both their leaves and their flowers in those parts which were nearest the ground; some time after they got fresh leaves, but no new flowers. Further, it is observable that the cold nights which happen in spring and summer never do any hurt to high grounds, damaging only the low and moist ones. They are likewise very perceptible in such places where limestone is to be met with, and though all the other parts of the country be not visited by such cold nights in a summer, yet those where limestone lies have commonly one or two every summer. Frequently the places where the limestone lies are situated on a high ground; but they suffer, notwithstanding their situation; whilst a little way off, in a lower ground, where no limestone is to be found, the effects of the cold nights are not felt. Mr. *Evans* was the first who made this observation, and I have had occasion at different times to see the truth of it, on my travels, as I shall mention in the sequel. The young hickory trees have their leaves killed sooner than other trees in such a cold night, and the young oaks next; this has been observed by other people, and I have found it to be true in the years 1749 and 1750." *

* Kalm, Vol. II., pp. 83-85.

The occurrence of a frost in June, having a like effect upon tender leaves of trees, has been referred to on another page.

One of the most remarkable of his inquiries was in regard to the weather and its changes and the permanency of climate. The answers of that day were substantially what might be obtained now. We quote: "The following account the old man gave me, in answer to my questions with regard to the weather and its changes: it was his opinion that the weather had always been pretty uniform ever since his childhood; that there happen as great storms at present as formerly; that the summers now are sometimes hotter, sometimes colder, than they were at that time; that the winters were often as cold and as long as formerly; and that still there often falls as great a quantity of snow as in former times. However, he thought that no cold winter came up to that which happened in the year 1697, and which is often mentioned in the almanacks of this country; and I have mentioned it in the preceding volume. For in that winter the river *Delaware* was so strongly covered with ice that the old man brought many waggons full of hay over it near *Christina*, and that it was passable in sledges even lower. No cattle, as far as he could recollect, were starved to death in cold winters, except in later years, such cattle as were lean, and had no stables to retire into. It commonly does not rain, neither more nor less, in summer than it did formerly, excepting that, during the last years, the summers have been more dry. Nor could the old *Swede* find a diminution of water in brooks, rivers and swamps. He allowed, as a very common and certain fact, that wherever you dig wells you meet with oyster shells in the ground.

"The winter came sooner formerly than it does now. Mr. *Isaac Norris*, a wealthy merchant, who has a considerable share in the government of *Pennsylvania*, confirmed this by a particular account. His father, one of the first *English* merchants in this country, observed, that in his younger years, the river Delaware was commonly covered with ice, about the middle of *November*, old style, so that the merchants were obliged to bring down their ships in great haste before that time, for fear of their being obliged to lie all winter. On the contrary, this river seldom freezes over at present before the middle of *December*, old style.

"It snowed much more in winter, formerly, than it does now; but the weather in general was likewise more constant and uniform; and when the cold set in, it continued to the end of *February*, or till *March*, old style, when it commonly began to grow warm. At present it is warm, even the very next day after a severe cold, and sometimes the weather changes several times a day.

"Most of the old people here were of opinion, that spring came much later at present than formerly, and that it was now much colder in the latter end of *February* and the whole month of *May* than when they were young. Formerly the fields were as green, and the air as warm, towards the end of *February*, as it is now in *March*, or in the beginning of *April*, old style. The *Swedes* at that time made use of this phrase, *Pask bitida, Pask sent, altid Gras*, that is, we have always grass at *Easter*, whether it be soon or late in the year. But perhaps we can accoont as follows, for the opinion which the people here have, that vegetation appeared formerly more forward than it does now. Formerly the cattle were not so numerous as now; however, the woods were full of grass and herbs, which, according to the testimony of all the old people here, grew to the height of a man. At present a great part of the annual grasses and plants have been entirely extirpated by the continual grazing of numbers of cattle. These annual grasses were probably green very early in the spring, and (being extirpated) might lead the people to believe, that everything came on sooner formerly than it does at present. It used to rain more abundantly than it does now; during the harvest especially the rains fell in such plenty that it was very difficult to bring home the hay and corn. Some of the last years had been extremely dry. However, a few people were of opinion that it rained as plentifully at present as formerly.

"All the people agreed, that the weather was not by far so inconstant when they were young as it is now. For at present it happens at all times of the year, that when a day has been warm, the next is very cold and *vice versa*. It frequently happens that the weather alters several times in one day, so that when it has been a pretty warm morning, the wind blows from northwest about ten o'clock and brings a cold air with it; yet a little after noon it may be warm again. My meteorological observations sufficiently confirm the reality of these sudden changes of weather, which are said to cause, in a great measure, the people to be more unhealthy at present, than they were formerly.

"I likewise found everybody agree in asserting that the winter betwixt the autumn of the year 1697, and the spring of the year 1698, was the coldest and the severest which they ever felt."*

*Kalm, Vol. II., pp. 119, 120, and 127-130.

CHRONOLOGICAL NOTES OF THE WEATHER.

REMARKABLE SEASONS; ICE IN RIVERS AND HARBORS; DROUGHTS, ETC., ETC., ETC.

[Abbreviations: W, Webster; H, Hazard; B, Blodgett; G, Gordon.]

The following brief notes of the weather have been gathered from S. Hazard's "Register of Pennsylvania," Vol. II., pp. 23–26 and 379–386, Philadelphia, 1828; Watson's "Annals of Philadelphia," 1844; Dr. Noah Webster's, "A Brief History of Epidemics and Pestilential Diseases," Hartford, 1798; Blodgett's "Climatology of the United States," Philadelphia, 1857; and from meteorological data from various stations in New Jersey and Philadelphia since 1843.

1607-8.—Winter extremely cold. W.

1631.—De Vries arrived in the Delaware about the first of February; the season was so mild that his men could work in the open air in their shirt sleeves; (the earliest notice of weather on the Delaware.) G.

1638.—Summer very hot and dry. W.

1639.—No rain from April 26th to June 4th, O. S. W.

1641.—Summer wet and cold; very sickly on the Delaware river; settlement from New Haven broken up, and Swedes suffered greatly. W.

1641-2.—Chesapeake bay nearly frozen over. W.

1656.—Summer very hot. W.

1678.—December 10th, the Shield arrived at Burlington; river frozen next day. G.

1681.—December 11th, Delaware river frozen over; the Bristol Factor arrived at Chester with settlers for Pennsylvania, where they lay all winter. H.

1683-4.—Winter was excessively severe. W.

1697-8.—Winter very cold. Kalm.

1704.—Snow fell a yard deep. H.

1708-9.—A very severe winter. W.

1714.—February; flowers seen in the woods. H.

1717.—February 19th-24th, great snow—"greatest ever known," up to that time, in New England and on Long Island. W.

1719-20.—Winter very cold. W.

1720.—February 23d, Delaware clear of ice. H.
December 20th, Delaware full of ice; 27th, again clear. H.

1721.—December 19th, Delaware full of ice. H.

1722.—February 6th, Delaware open again to navigation. H.

1723.—January 6th, Delaware free from ice, and weather yet moderate. H.

1723–4.—December and January, river open. H.

1724.—December 15th, Delaware full of ice. H.

1725.—March 3d, snow two feet deep. H.

1725–6.—December 21st, Delaware full of ice until January 18th.
February 1st–15th, again blocked with ice. H.

1727.—February 14th, very cold weather. H.
Summer hot. W.

1728.—January 23d, severe weather for two weeks; booths set up on the Delaware; no clearances of vessels mentioned until March 5th. H.

1729.—December; Delaware open all the month. H.

1730.—January 20th, a deep snow; the like not known these several years; navigation closed. H.
December 21st, vessels forced back by ice; 29th, open. H.

1731.—February 9th, Delaware open again. H.

1731–2.—Delaware full of ice on December 14th; February 22d, navigation unobstructed. H.

1732–3.—December; Delaware open; January 18th, great snow at Lewes; March 8th, river open. H.

1734.—January 1st, Delaware continues open; very moderate weather. H.
December 21st, weather fine and open; Delaware free from ice. H.

1735.—January 16th, weather fine and open; Delaware free from ice. H.
December, weather fine and open; Delaware free from ice. H.

1736.—January 6th, Delaware fast and full of ice; February 5th, open. H.
December, Delaware open. H.

1737.—January 20th, weather very cold; February 3d, ice broke up in Schuylkill. H.

1738.—January and February, Delaware open. H.

1739.—January 25th, Delaware now open, having been fast since December 18th. H.

1739–40.—December, Delaware open; January 10th, closed; February 21st, arrivals; March 15th, ice broke up. H.

1740–41.—An exceptionally cold winter. Jefferson says that it was only less severe than that of 1779–80. B. Long Island Sound frozen over three leagues across. W. Delaware not navigable from December 19th until March 13th; January 8th, at Lewes, Del., 'tis all ice towards the sea as far as the eye can reach; snow 3 feet deep in back country. Much suffering among inhabitants and cattle. H.

1741–2.—Delaware open during December and January, and no mention of ice in February and March. H.

1742–3.—Another open winter. H.

1744.—January 3d, Delaware full of ice; January 19th, open. H.

1744–5.—No mention of ice, clearances and entries in all the winter months. H.

1745–6.—No ice mentioned, entries and clearances in December. H.

1746–7.—Delaware closed (no arrivals) from December 23d to February 24th. H.

1747–8.—December 15th, Delaware full of ice; January 12th, open; 26th, closed, and severe weather; February 2d, open; 9th, closed until March 1st. H.

1748–9.—Delaware open during December; closed in January; February 14th, arrivals. H.

1750.—January 22d, Delaware opened; February 6th, free of ice; May 30th, frost last week and snow in places. H.

1750–51.—Very severe winter. W. Delaware open January 22d. H.

1751–52.—Delaware full of ice, December 24th; clear again, February 18th. H.

1752.—A summer marked by intense heat in all parts of America. Sickly. W.

1753.—January 2d, navigation on Delaware stopped; January 9th, open; 23d, clear. H.

1754.—January 15th, Delaware for some days clear of ice. H.

1754–5.—Winter unusually mild. Troops sailed from New York to Albany in January and February. W. January 14th, Delaware stopped; 21st, clear again. H.

1755–6.—Another mild winter. W. No mention of ice in the Delaware this winter, and entries and clearances every month. H.

1756–7.—No mention of ice in the Delaware, and entries and clearances throughout December and January. H.

1757–8.—Delaware open in December; February 2d, closed for few days. H.

1758–9.—December 28th, Delaware full of ice; January 11th, open; 25th, interrupted; February 1st, open. H.

1759–60.—December 28th, Delaware closed for a week; February 14th, open; March 20th, extraordinary snow storm, and greatest fall of snow since the settlement of the province. H.

1760–61.—No entries or clearances at Philadelphia from January 15th to February 5th. H.

1761–2.—December 17th, Delaware interrupted by ice for several days; December 24th, quite stopped; January 21st, open. H.

1762.—Heat and drought exceeded what was ever known before; from June to September scarcely a drop of rain; forest trees scorched. W.

1762–3.—Snow fell November 8th, and it lay until March 20th. W. Delaware open in December; January 13th, stopped for some days. H.

1763–4.—Delaware open during December and January. H.

1764–5.—Navigation in the Delaware much obstructed by ice from December 27th until February 28th; February 7th, an ox roasted whole on the ice at Philadelphia. H. March 28th, snow fell two to two and one-half feet deep on a level (last Saturday night and Sunday). H.

1765-6.—Delaware open until January 9th; February 6th, arrivals. H.

1766-7.—Delaware open until January 1st; a thaw, January 8th. H. At Brandywine, Del., 20° below zero. W.

1767-8.—Delaware closed for a day or two, December 24th; clear of ice, February 11th. H.

1768-9.—Navigation throughout December and January. H.

1769-70.—December 21st, navigation at a stand for several days; February 15th, river clear. H.

1770-1.—December, Delaware open; January, Delaware open; February 14th, river full of ice, stopping navigation; 28th, clear. H.

1771-2.—December 26th, Delaware full of ice; January, excessively cold month; February 20th, river open; March 16th, snow in many places two feet deep; much ice in river. H. April 2d, snow fell in several places six inches deep. H.

1772-3.—January 20th, Delaware full of ice; 21st, very cold; March 3d, navigation opened. H.

1773-4.—Delaware open in December; stopped January 12th, and February 14th, still fast. H.

1774-5.—December 30th, ice in river; open January 17th. H.

1778.—Summer very hot. W.

1779.—January 19th, Delaware closed; February, leaves of willows, blossoms of peach, and dandelion flowers were seen. H.

1779-80.—Coldest winter since 1740-41; from November 25th to middle of March cold was intense and almost uninterrupted; snow nearly four feet deep for three months; the sound was entirely covered with ice between Long Island and the main, and between New York and Staten Island. W. Troops crossed from New Jersey to Staten Island on the ice; the Delaware river was closed from the first of December to the fourteenth of March—the ice being two to three feet thick. B. During the month of January the mercury in Philadelphia did not rise to the freezing point, excepting one day. H.

1780.—May 19th, dark day, which reached as far south as New Jersey. W. Summer hot. W.

1780-81.—January 27th, winter thus far remarkably mild, so that the earth has scarcely been frozen half an inch deep. H.

1782.—January, Delaware frozen up since December 30th; closed to February 16th. H.

1783.—November 28th, navigation in Delaware stopped, and river frozen over until March 18th. B.

1784.—January, a thaw for two days; then a fall of fifty-three degrees in a few hours. H. Summer extremely hot at Hartford. W.

1784-85.—December 26th, Delaware navigation at a stand; open January 3d; closed again 4th; open last of January; February 2d closed. H.

1786.—January 26th, mild winter until middle of January; May, remarkable for the absence of the sun for two weeks, and a constantly damp or rainy weather. H.

1786-7.—Winter began early and was very severe. W.

1788-9.—A severe winter; the Delaware was closed from December 26th to March 10th; at Hartford, Conn., 28° below zero, February 2d. W.

1789-90.—Very open winter; February 7th to 17th, Delaware stopped with ice; March 10th, only considerable snow of the winter—remaining on the ground three days. H.

1790-91.—Delaware closed from December 18th to January 18th. H.

1791.—Excessively hot summer. W.

1791-2.—Delaware closed December 23d to end of month. H.

1792-3.—Delaware open during December; April weather in middle of January.

1793.—April 1st, blossoms universally—two weeks earlier than usual. H.

1793-4.—Very mild winter; lowest in New York, 13° above zero. W. January 13th, Delaware open. H.

1794-5.—Mild weather until middle of January; the Delaware closed from January 21st to 26th. H.

1795-6.—Winter most moderate for forty-five years; navigation interrupted on Delaware for one week in February by driving ice. H. The Hudson river closed by ice at Albany, January 23d, 1796.

1796-7.—Delaware closed, December 23d; Susquehanna closed, December 6th; January 10th, as cold weather as remembered in fifty years. H. At south and west extremely cold. W.

1797-8.—Winter long and cold; Hudson river closed in November. W. Delaware frozen over, December 1st; open again, February 5th. H.

1798-9.—A long and severe winter, with much snow; March 12th, deep snow. H.

1799.—Cold weather in spring; ice, April 20th; frost, June 6th. H.

1799-1800.—A remarkably open winter until January 6th; Delaware open again on 18th. H. Snow 3 feet deep in Georgia; snow and hail at St. Mary's river, in Florida. B.

1801-2.—February 22d, no obstructions this winter to impede navigation in Delaware, except floating ice. H.

1802-3.—Delaware frozen over December 19th. H.

1803.—May 7th, ice; on the 8th, a snow which broke down the poplars and other trees in leaf. H.

1804.—January 1st, vessels come and go on Delaware as in summer. H. January 21st, river full of ice; March 5th, still frozen; clear on March 7th. H.

1804-5.—Delaware obstructed by ice, December 18th; February 28th, again navigable; a variable winter. H.

1805.—Summer; no rain after middle of June; all through July, heat 90°-96°. Watson.

1805-6.—An open winter; Hudson river free from ice, February 20th. H.

1806-7.—Navigation stopped December 18th until 20th. H.

1807-8.—Delaware open until January 11th. H.

1808-9.—Delaware open until January 5th, then much ice drifting at Cape May. H.

1809.—April 13th, snow; 26th, ice as thick as a dollar. H.
May 6th, ice; 13th, frost; cold May. H.
November 24th, snow one foot deep; sleighing. H.

1810.—January 10th, first ice of the season in the Delaware; river closed and opened several times; clear February 11th. H.
Hudson river open until January 19th. H.

1810-11.—Navigation on Delaware stopped December 18th; open early part of January; ice in February. H.

1811-12.—December 25th, Delaware full of ice; January 12th, river fast until February 8th. H.

1812.—May 4th, rain and snow; spring very backward. H. Memorable as a "cold summer." B. Very wet at harvest. W.

1812-13.—December 9th, Schuylkill fast; Delaware full of ice; January 11th, Delaware full of ice; February 26th, open. H.

1814.—January 9th, Delaware closed to navigation; February 2d, open and arrivals. H.

1814-15.—December 15th, Floating ice in Delaware; March 5th, ice cleared. H.

1816.—Summer cold; both 1812 and 1816 were memorable as "cold summers" for all the northern United States; from May to September of 1812 each month was from 3.6° to 7.2° below the average; June and July, 1816, were 5° and 5.8° below; in the northern States snows and frosts occurred in every month of both summers; Indian corn did not ripen. B. Frosts at Philadelphia in June, July and August. B. & H.

1817.—January 19th, Delaware closed; March 9th, opened. H.

1817-18.—January 31st, Delaware closed; February 28th, opened. H. Hudson river closed for 108 days, until March 25th.

1818-19.—Winter severe in New England. B. Delaware was obstructed by ice in December; open in January for a time. H. Hudson river free from ice April 3d.

1819.—October 25th, snow in southeastern Pennsylvania. H.

1819-20.—December, Delaware open; February 4th, bay full of ice. H.

1820-21.—"This winter was one of four during a century in which the Hudson, between New York and Paulus Hook, was crossed on the ice." B. It closed November 13th, but opened again on 20th; closed December 1st; Delaware open during December; open February 14th. H.

1823.—January 22, navigation in Delaware clear. H.

1824-5.—December, Delaware open; February 14th, clear of ice. H. Hudson river open until January 5th, 1825.

1824.—July 29th, 4½ inches of rain fell at Philadelphia; 11 inches at Germantown.

1825–6.—A cold winter; December 28th, ice in Delaware; January 31st, closed until February 8th. H.

1826–7.—Delaware open during December. H.

1827–8.—Navigation uninterrupted on Delaware this winter; ice-houses unfilled. H. The Hudson at Albany closed for 43 days only; February 8th, free from ice.

1828–9.—Hudson river closed December 23d; free from ice April 1st.

1829–30.—Hudson river at Albany closed January 11th (1830); and free from ice again March 15th.

1830–1.—Winter very cold at southwest; ice formed at New Orleans. B.

1835.—January and February both very cold; February 8th, thermometer fell below zero, nearly all over the country north of Savannah and Natchez; Long Island Sound was closed by ice; coldest winter since 1779–80. B.

1837.—Summer mean temperature, low. B.

1843.—March was coldest month of *winter* of '42–43; snow 15 inches deep in Georgia. B. August, a remarkably heavy rainfall at Newark, 22.84 inches; at Lambertville, 15.26 inches; Hudson river free from ice at Albany, April 13th, having closed November 26th, 1842.

1844.—January cold; spring, warm; summer, below the mean temperature.

1845.—January, warm; minima, 8° to 18° above zero; minima for winter of 1844–45, 3° to 6° above zero.

1846.—Winter of 1845–46, colder than usual, but no very low temperatures; spring and summer cooler, and autumn warmer than average seasons.

1848.—Winter of 1847–8, warmer than average.

1849.—Below zero in January and also in February; autumn, warm.

1850.—Mean temperature for the year, high; winter of 1849–50, warm; minima, 3° to 8° above zero; autumn remarkable for its high mean temperature.

1851.—Winter of 1850–51 also warmer than average; no temperatures below zero recorded.

1852.—Winter of 1851–2, cold; mean temperatures of the months, 3° to 8° below the average; East river crossed on the ice January 30th, and for three days following; Susequehanna at Havre de Grace frozen over for seven weeks; cold and snows as far south as New Orleans and Jacksonville, Fla. B.

1853.—A warm year; range of temperature 2° to 98°; winter of 1852–3, one of the warmest on record; and very wet, the rainfall at Newark having been 15.85 inches.

1856.—One of the coldest years in our records; the first three months of this year very cold. A. Reproduction of 1779—80; March had minima of 0.75° below zero to 4° above; in April the lowest temperature at Lambertville was only 17°; the mean temperatures for each of the spring months were below their averages since; Long Island sound was closed to navigation from January 25th to February 27th; New York harbor was much obstructed by ice, and that of Philadelphia was closed until late in March; the Hudson river did not open until April 10th. B. The rainfall at Newark for the year only 34.07 inches.

1857.—Followed as another cold year; and the mean temperatures for the winter of 1856-7, of the following spring, summer and autumn were all low; all of the winter months were marked by low temperatures, and in January of this year the cold was intense; On the 24th, readings of 1° to 20° below zero were recorded, and the highest reached 35° to 47° only; the means for the month were 16.22° to 22.06°; like 1856, the spring months were colder than the average; the summer was notable for its absence of extremely high temperatures, and its mean was low; altogether it was an exceptional year.

1858.—The cold seasons of 1857 were succeeded by the warm winter of 1857-58, although in February the thermometer, at several localities, fell to 6° to 8° below zero.

1859.—The year was exceptional in its cold summer; at Newark, the coldest in thirty-eight years, and 3.2° below the average; the July mean was nearly 4° below the mean for the summers of the whole period; at Lambertville the difference was 1.4°; the maximum, however, ranged from 91° to 100°; all the seasons were wet.

1860-62.—These years were noted for their rather cooler summers, and the absence of excessively high temperatures; February, 1861, was marked by depressions of 2° above zero to 7.5° below zero.

1863.—The winter of 1862-3, like those of 1859-60 and 60-61, was also characterized by its minimum occurring in February.

1865.—January was cold; the extremes were 11° below zero and 57° above.

1866.—This year was everywhere one of great range of temperature; the mean temperatures of the months and seasons were not far from the average; January 8th, the readings ranged between 9° and 20° below zero, at the several stations in New Jersey, and in the adjacent parts of Pennsylvania and New York; on the 17th of July, the maxima at these same places were 92° to 102°, making the range for the year 107° to 114°; in this respect the year is altogether exceptional.

1867.-Unlike the last, 1867 was more even in temperature, the range being from 0.5° degrees to 88° at Newark; the spring and summer were cooler and the autumn a little warmer than the means for 38 years; the year was wet, and the summer rainfall at Newark amounted to 24.11 inches; at Philadelphia, Pa., to 30.82 inches, and that for the year to 62.94 inches—a great excess.

1868.—The winter of 1867-8 was cold; at Newark it was the coldest of the thirty-eight-year period; and on forty-seven days the thermometer did not rise above freezing (32°). In February, records of 3° to 10° below zero were made at several stations, and the mean for that month ranged from 5° to 10° below the average; it was the coldest February observed at Newark; the total depth of snow was six feet three inches, the deepest in the series; March and April were cold, and freezing weather continued to the middle of April; the Hudson river was not open to navigation at Albany until April 5th; the yearly mean was also lower than usual.

1869.—The winter of 1868-9 had no extremely cold weather, and the lowest temperatures were 3° to 8° *above zero;* the Hudson river closed early—December 5th.

1870.—Again in 1869-70 the winter was warm and remarkable for its low range of temperature; the lowest readings did not reach zero, and the average among the several stations was between 5° and 13° above; the mean temperature for January ranged between 33.9° and 40.7°; February was colder throughout, and was the coldest month of the winter; the summer was above the average temperature; and on June 28th and July 17th, the thermometers at all of the stations registered 92° and upwards; the mean at Vineland, for July, reached 80.3°; the yearly mean, also, was above the usual figures.

1871.—The extremes of the winter of 1870-71 were quite low in all the months, although the average was high; the spring was warmer than usual, and readings of 82° and upwards occurred in April; a depression of 1° to 6° below zero took place in December (21st); the Hudson river closed at Albany very early—November 29th.

1872.—The spring was colder and the summer warmer than the means for those seasons show; March, at Newark, was the coldest in the 38 years of observations.

1873.—The winter months (1872-73) all were remarkable for low temperatures; the minima of December, 1872, were zero to 7° above; those of January, 1873, were between 0.5° and 22° below zero; the depression over the northern half of the State was severe, (12° to 22° *below zero*); in February, also, the observations showed readings for zero to 6° below zero; the Newark record shows that in 43 days the thermometer did not rise above freezing; the Hudson river was closed from December 9th to April 16th.

1874.—The year was notable for its lesser range of temperatures than ordinary.

1875.—A cold year; its mean temperature at Newark, only 48.2°, or nearly 3° below the average, and the coldest in the series; the winter of 1874-75, the following spring and autumn were all cold; the spring and autumn were the coldest observed at Newark, in that all the months were either below or little above the average mean; and the monthly ranges were generally small; the highest temperature in January, in the northern part of the State, was 41°; the lowest 8° below zero; the summer was very wet.

1876.—The winter of 1875-76 was comparatively mild, and the lowest readings did not go below zero; and the average of the winter months was above freezing; the summer was remarkable for its long continued heat, and its severe drought; the records show maxima of 90° and upwards for each of the summer months at all the stations; the mean monthly temperatures range from 70° to 80° at very nearly all of them; the rainfall at Newark was little more than half the usual depth.

1877.—The winter of 1876-77 was cold; December, at Newark, had a mean temperature of 23.81°, the lowest in the 38 years' period; the month corresponded to our January, ordinarily; the Hudson river closed at Albany on the 2d of December, and did not open until March 30th; the summer of 1877 was the warmest in the Newark series; high temperatures were reported at all the stations, and the means for the several months of the summer were all high; the autumn, also, was warmer than usual; and the observations showed a lesser range generally; no readings below freezing (32°) were recorded in October, and the length of the seasons between frosts was much greater than common; the Moorestown record shows 203 days, from April 13th to November 4th [See page *32]; December, of this year, is noted for the entire absence of snow in all the central part of the State (the average snowfall at Newark, in December, is about 9 inches); the total rain and snow was 0.92 inches at Newark.

1878.—The winter of 1877-78 had a high mean temperature; it was marked by a slight range—2° to 67°, at the several stations; the snowfall at Newark was but 1 foot 2 inches in depth; the Hudson river did not close until December 31st; the spring was unusually warm, and the month of April was the warmest in the Newark series, its mininum being 40° and its mean temperature 55.55°, or within 5° of the average May temperature; the summer, also, was warmer than the average, and July was a hot month throughout; and the maxima were from 93° upwards; The yearly mean temperature at Newark was 53.63°, the highest in 38 years.

1879.—The winter of 1878-79 ranked among the colder winters; the low mean temperature was due to steady cold weather, and not to excessive depressions; the Hudson was closed between December 20th and April 4th—100 days; July was marked by a high maximum—at Newark, 98.25°, the highest there observed; the autumn was remarkably dry, the rainfall at New Brunswick amounting to 3.58 inches only.

1880.—This year was exceptional in several particulars; the winter, ending with February, was the warmest on record; its average temperature at Newark was 35.91°, or 1.19° above the warmest previously observed; the average for January at the same place was 37.64°, or 18.31° above that of January, 1857; the range of means throughout was 31.4°, at Port Jervis, to 43.6°, at Cape May; in the northern counties no observations below zero are given, and in the southern part of the State the lowest readings were 8° above zero; May of this year was also remarkable for its hot weather, surpassing that of all preceding years observed; the mean at Newark was 68.38°, and the range 96° to 35°; at Princeton, the maximum, minimum and mean temperatures were 97°, 37° and 67°, respectively; at Atco, 97°, 32° and 70°, and the mean for the month was very nearly as high as that of June; the spring was also very dry; the latter part of the year was cold, and winter began in November; at the close of December there was a sharp depression, and the thermometer registered minima varying from 6° to 17° below zero in the counties north of Cape May; the mean daily temperature, December 30th, at New Brunswick, was 3.5° *below zero;* at Freehold, the mean was 3.62° below zero; the drought of the earlier part of the year was such that wells and springs were lower than for 38 years past.

The tables of this article nearly all end with 1880, but the year 1881 has been so remarkable that it is included in this list of notes.

1881.—The last winter was unusually steady and cold; its mean temperature at Paterson was 26.25°, or 4° below the average there; at New Brunswick, 25.11°, or 4.78° below the mean; the range of temperature was from 7° below zero to 52° above; *for* 153 *days, from November* 22*d*, 1880, *to April* 23*d, inclusive, the average temperature was* 29.28°, *or the mean for the three winter months* at New Brunswick; heavy snowfalls in southern part of State; at Freehold 75.4 inches of snow; the Hudson closed at Albany on 25th November; the heat of the summer and autumn also were remarkable; and the highest temperatures of August, September and October, as observed at New Brunswick, are not equalled by those of the corresponding months of any previous year; the 7th of September averaged 89.75° at Newark; the maximum was 100.5°, "*above that of any day in any month, in any year during* the whole period." [For a notice of the drought see page *78.]

An examination of these notes shows the great variation in our seasons when the comparison covers a period of two centuries, and the range is much greater than would be observed in a term of thirty or forty years. Many of our records are limited to periods of ten years, and few exceed twenty years in length. We learn how incomplete exhibits of our climate in all its extremes they are. The averages or means may be very close, but the range is too short. Of course many of the earlier notes are very fragmentary, and give results of great heat and severe cold instead of any proper meteorological measurements of their intensity. However, the winters of 1740–41, of 1779–80, of 1820–21, and of 1856; the snows and ice in May, 1808; the frosts every month in the summer of 1812, and again in that of 1816, are quite as decisive and emphatic as any thermometric records would be, and they indicate to us the possibilities in weather phenomena. In short, they may occur again, and the experiences of the past be repeated in our time. They constitute a striking illustration of the uncertainties of the weather, and in them we discover no law which would enable us to predict the seasons in advance, or solve the problem of meteorology.

NOTE.—It is pleasant here to record the generous assistance which has been given by observers and others interested in the study of our climate. The names of those who have contributed data for this work are mentioned in the text, in the tables and in the foot notes.

The drawings for the plates were made by C. C. Vermeule, C. E., Topographer of the Geological Survey.

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