

Warnings were therefore issued on the 23d and 24th well in advance, and by the morning of the 26th the cold had extended over the entire district.

Several warnings were sent to open ports on Lake Michigan when severe storms were threatened. However, winter navigation was retarded more by ice than by windstorms. No losses to shipping have been reported.—*H. J. Cox, Professor and District Forecaster.*

ROCKY MOUNTAIN FORECAST DISTRICT.

Early on the 2d warnings of a cold wave were given general distribution in Utah, Wyoming, and eastern Colorado, with the information that high westerly winds were indicated for Utah and westerly shifting to high northerly winds for Wyoming and eastern Colorado. This storm proved to be the most severe of the winter, on account of the high winds that accompanied it, together with an unusually great and rapid fall in temperature. Warnings were also given distribution in Wyoming and northeastern Colorado during the morning of the 9th. On the 23d warnings were issued for Utah, Wyoming, and eastern Colorado, and were renewed the following morning in southern Wyoming and eastern Colorado.—*F. H. Brandenburg, District Forecaster.*

SOUTH PACIFIC FORECAST DISTRICT.

The month was unusually stormy, and while the intensity of the rain in central California has been exceeded in other Marches, the frequency, or number of rainy days, broke all records. In northern California the rainfall was so heavy as to cause serious floods in the Sacramento River and its tributaries. Storm warnings were displayed with unusual frequency, and warnings of rapid rises in the rivers of northern California were issued.—*A. G. McAdie, Professor and District Forecaster.*

NORTH PACIFIC FORECAST DISTRICT.

In the North Pacific States the month was unusually cold and stormy, and heavy snow in the mountains of eastern Oregon resulted in disastrous avalanches. The windstorms of the 10-11th and 19th were very severe, the wind on the 10th reaching a velocity of 84 miles an hour at North Head, Wash. Timely warnings were issued for the gales of the month.—*E. A. Beals, District Forecaster.*

RIVERS AND FLOODS.

The ice situation in the principal rivers of the United States during the month may be summarized as follows:

In northern New England the ice remained firm throughout the month and in southern New England until about the 20th. At the opening of the month the Mississippi River was frozen from Davenport northward, and the Missouri River north of Sioux City. At the close of the month the Missouri River was frozen from Bismarck northward, and the Mississippi north of La Crosse, with floating ice observed at considerable distances below these places. There was no ice of consequence in the Ohio and Potomac rivers.

The ice gorges that formed in the Susquehanna River in January continued until the latter part of the month, causing numerous floods and the loss of a large amount of property. The following report on these gorges was prepared by Mr. E. R. Demain, official in charge, United States Weather Bureau office, Harrisburg, Pa.:

The ice which broke up on the Juniata during the latter part of February gorged near Duncannon. On the morning of March 2 the ice at the mouth of the Juniata moved, increasing the size of the gorge at Duncannon and causing the flooding of some houses and industrial plants. The ice on the West branch broke at Lockhaven about 2 p. m., March 3, and moved out on a 12-foot flood. Warnings were immediately wired to Williamsport and Selinsgrove on the receipt of the information, and the postmaster at Duncannon was informed that the flood from the West branch would probably increase the danger from backwater at that point. The Paxton furnaces and other industrial plants in south Harrisburg and Steelton were advised to prepare for a big flood, and this

was done in many instances. When the flood from the West branch reached Duncannon on the morning of March 4 it swept away the gorge at that place without destroying the Clarks Ferry bridge, which was thought by many to be in great danger, and the whole mass of ice and water moved down, breaking up the ice on the river as it advanced. The ice broke at Fort Hunter, 7 miles above Harrisburg, at 10:05 a. m., March 4, and at 10:55 a. m. the ice began to move at Harrisburg, the water rising steadily from 13.5 feet at 8 a. m. to 16 feet at noon. Between noon and 1 p. m. the river at Harrisburg rose 4 feet, to a stage of 20 feet. After 1 p. m. the rise was more gradual until 3:15 p. m., when 23.3 feet was registered on the gage at the pumping station. The water receded slowly from that time till 11 p. m., when the stage was 21.3 feet. The ice at Harrisburg broke on both sides of the island at the same time. This great mass of ice, moving down and increasing the congestion below, formed a gorge near Middletown and another a short distance below Highspire. The ice on the west side of the island at Harrisburg soon stopped, but the ice in the east channel continued to move till about 2:30 p. m., when the channel became choked. About 4:30 p. m. the ice in the west channel began to move, and this channel continued open the rest of the day. All the lowlands from south Harrisburg to Middleton, a distance of about 9 miles, were submerged, the water at Middletown being 1.5 feet higher than in the great flood of June 2, 1889, and at Highspire about 0.8 of a foot higher, but by midnight the water at both of these towns had receded about 2 feet.

No material changes occurred in the situation in the main river or in the gorged districts of the North branch from the evening of March 4 till the morning of the 8th, the water in the pools above the gorges fluctuating during this time as the gorges opened and again became choked with floating ice. The Juniata, West branch, and the headwaters of the North branch began to fall on the 4th, the fall continuing until the morning of the 7th, when rain and milder weather occurred over the whole watershed. This started a rise in all streams, and by the night of the 7th all the branches of the system were rising rapidly. On the evening of the 7th Catawissa reported that the ice had moved off Roaring, Catawissa, and Nescopeck creeks, taking away several wagon bridges. The ice moved at Harrisburg, above the upper bridge, at 6 a. m. on the 8th, but the movement continued only a few minutes. The river continued to rise steadily during the morning; at 7 a. m. it registered 21.2 feet and at 10 a. m. 22.3 feet on the Harrisburg gage. At Middletown and other points below Harrisburg, nearer the Middletown gorge, the rise was more rapid. At Middletown the water reached a stage of 34.5 feet about 10 a. m., the highest ever known and said to be 5 feet higher than the flood of June 2, 1889. The excitement at Middletown, Highspire, Steelton, and Harrisburg was great; the telephone in the office was in use constantly during the morning, requiring the attention of an observer to answer the calls for information. Hundreds of people desired to know how much more water was expected, a question which it was impossible to answer definitely; they were informed that the only hope of early relief was in the breaking of the gorges at Middletown and Highspire. Fortunately this occurred about 10 a. m. and at once relieved the seriousness of the situation at Middletown and a little later at Highspire, Steelton, and Harrisburg. The river began to fall at Harrisburg about 10:15 a. m., but the ice did not begin to move till about 11:40 a. m. All the bridges at Harrisburg stood the shock well, except the new Market Street Bridge; several large stones were knocked out of the twentieth pier of this structure, from the Harrisburg side, by heavy cakes of ice, damaging it to such an extent that it was found necessary to close the bridge to traffic. This bridge had been in use only about ten days. Immediately steps were taken to protect the damaged pier, and a wooden "nosing" was hastily constructed and placed over the damaged part before any further movement of heavy ice occurred. This doubtless saved the pier from destruction. The bridge was opened to traffic again early on the morning of March 12.

While the breaking of the Middletown gorge greatly lessened the danger on the main river, the conditions in the gorged district of the North branch were becoming more serious. At Wilkesbarre the river was 29 feet at noon, and the situation in the vicinity of Bloomsburg and Catawissa continued very serious. Early in the morning of the 8th the ice began to move at Wilkesbarre, the movement continuing for about two hours; the ice then gorged solidly and remained stationary the rest of the day. The ice also moved at Boyds, between Catawissa and Danville, early on the 8th. The gorge at Bainbridge, below Harrisburg, was reported to have started on the 8th, moving down on and dislodging the gorge at Turkey Hill, the accumulated ice and water rushing down and gorging below Safe Harbor, submerging the low parts of that town and destroying many houses and one or two county bridges. The ice broke at Pittston, above Wilkesbarre, about midnight of the 8th and moving down lodged on the gorge at Nanticoke, the water rising at 30.6 feet at Wilkesbarre about 1:30 a. m. of the 9th, flooding more houses and causing several coal companies to suspend operations. The ice moved about 400 feet at Catawissa at 11:30 a. m. of the 9th, carrying away the two east spans of the Catawissa Bridge which lodged near the east shore. Several other movements of ice occurred in the North branch on the 9th, and as these movements indicated a general break up of the ice gorges warnings were sent to Selinsgrove and other points below Sunbury to the effect that in case a general break occurred a disastrous flood might

be expected. The wires to Catawissa and Bloomsburg went down during the afternoon. The ice started at Danville about 3:30 p. m. of the 9th, carrying away the bridge at that point. About 5 p. m. the ice began to move at Wolverton, a few miles above Sunbury, and at 8 p. m. the observer at Sunbury reported the ice running between Sunbury and Catawissa and passing out of the North branch on a high flood. Later reports, however, showed that only that portion of the great gorge between Sunbury and Boyds passed out, and that the gorge above was still holding. The ice flood carried away three spans of the wooden wagon bridge at Sunbury, between Packers Island and Northumberland soon after 8 p. m., but did no damage to the steel bridges of the Pennsylvania and Philadelphia and Reading Railroad companies. These bridges were weighted with heavy trains of cars loaded with pig iron.

The spans of the wrecked bridges above were swept down on the ice flood and crashing against the Pennsylvania Railroad bridge were mashed to pieces, the broken timbers passing under the structure. Several large pieces of the spans of the wrecked Danville and Northumberland bridges passed Harrisburg between 7 and 8 a. m. of the 10th. The excitement was great at Harrisburg when it became known that the ice flood was coming out of the North branch on the evening of the 9th. It required the entire time of one observer to answer inquiries on the telephone. It was announced that the Weather Bureau office would remain open all night, if necessary, or in any case until it was known that there would be no danger at points below Sunbury. As the 10 p. m. and midnight reports from Selinsgrove and Sunbury showed that only a section of the great gorge had moved and that no danger threatened, the office was closed at 2 a. m. on the 10th. A section of the gorge between Boyds and Rupert moved out at 2 p. m. on the 10th, causing the river at Catawissa to fall 14 feet and improving the situation at Bloomsburg, where the water fell at the rate of about six inches an hour during the afternoon. A section of the gorge from Rupert to a distance of about three hundred yards above Bloomsburg Bridge moved out about noon on March 11 without destroying the Bloomsburg Bridge, which settled back on its piers. The river at Bloomsburg registered 24 feet when the ice began to move, and fell to 12 feet shortly after the movement occurred; the ice was reported to be 6 feet thick when it started. No further movement of ice was reported until March 21, when the gorge above Wilkesbarre began to disintegrate and move past Wilkesbarre. A portion of the gorges in the Susquehanna and Chenango rivers, near Binghamton, moved out during the afternoon of the 24th. The ice at Bloomsburg, which was near the center of the great gorge, began to move at 7:05 p. m. on the 24th, and the gorge broke at Creasy at 3:30 a. m. of the 25th. This gorge, which began about three hundred yards above the Bloomsburg Bridge, moved out quietly, without damage, the piers of the Bloomsburg Bridge cutting it nicely. The ice from these gorges began to pass Harrisburg about 3 p. m. of the 25th, about three-fourths of the river's surface being covered.

It is impossible to estimate with any degree of accuracy the damage done by ice floods in the Susquehanna River during the months of January, February, and March. The amount of damage sustained has been given by some newspapers at from \$2,000,000 to \$6,000,000 in the North branch. The loss in bridges alone probably exceeds a million dollars. The loss to railroads and electric lines was very great, thousands of additional laborers being required to clear the roadways of ice. The loss in property at Middletown has been estimated at from \$60,000 to \$75,000, and the loss in property from Sunbury to Wilkesbarre was very great.

From January 24, the day the gorge formed at Bloomsburg, until it was known that all danger had passed, every effort was made by this office to impress on the people, by bulletins and through the newspapers, the gravity of the situation, and the fact that not a single life was lost, although some narrow escapes from death occurred, is evidence that the repeated warnings were heeded by the public.

Floods of considerable magnitude occurred from the 25th to the 27th, inclusive, in the valleys of the Mohawk and Hudson rivers, caused by the breaking up and gorging of the large amounts of ice that had accumulated during the exceptionally severe winter. Considerable damage was done to property interests along the river, bridges were injured and railroad traffic much delayed. Timely and accurate warnings were issued and were the means of saving a large amount of property. The press and public were most liberal in their praises of the River and Flood Service maintained by the Weather Bureau.

In the Pittsburg district, flood stages were reached on March 1 and 2, also on the 7th and 8th, due to heavy rains and the rapid melting of the snow in the territory drained by the Allegheny and Monongahela rivers. Warnings were issued well in advance of the expected rises, and no damage of consequence was reported.

In the Mississippi and Missouri rivers, no extremely high water occurred. From the 15th to the close of the month

there was a gradual rise in both rivers, and in a few cases the danger line was reached, but there were no losses of importance.

During the first week of the month, considerable damage was caused by floods in the Sandusky River, in northern Ohio, particularly in the vicinity of Fremont. Flood stages were also reached in the Muskingum River, in southeastern Ohio from the 4th to the 6th.

There were also floods of considerable importance in the White and Wabash rivers of Indiana, during the latter part of the month. The damage was especially heavy at Indianapolis and vicinity, where many thousands of dollars worth of property was destroyed. These floods were caused by the excessive rains over the territory embraced in the above-named rivers and their tributaries.

One of the most destructive floods of the month occurred in Michigan, along the Grand, Shiawassee, and Kalamazoo rivers and their tributaries. The heavy rains and the sudden rise in temperature caused the rapid melting of the accumulated snow, and the rivers were quickly filled beyond their capacity, with the consequent flooding of all property interests along their courses. Very heavy losses are reported from Grand Rapids, Bay City, Saginaw, and in fact from all cities and villages in the district drained by the above-mentioned rivers. Bridges were washed away, railroad right of way destroyed, factories flooded, and all property in the basins of these rivers more or less injured.

Another destructive flood of March occurred in the valleys of the Sacramento and San Joaquin rivers of California. A description of this flood prepared by Prof. A. G. McAdie, official in charge, United States Weather Bureau office, San Francisco, Cal., follows:

The month of March, like the month of February, was one of excessive precipitation, and the additional water, augmenting the already large volumes in the basins of the lower Sacramento Valley, caused heavy floods and considerable loss to the farming industries of the Yolo, Sacramento, and lower San Joaquin basins.

Staten, Tyler, Bouldin, Jersey, and Sherman islands were flooded. Ryer Island was saved by untiring work upon the part of those in charge, but the water rose to within a few inches of the top of the levee, and the washing was so considerable that an inspection made on March 30 made it plain that a few hours more of strong wind would undoubtedly have broken the levees. Grand Island stood the strain well; but had Ryer Island gone under, it is an open question whether the rush of the water would not have endangered Grand Island, also.

The break on Sherman Island undoubtedly contributed to the escape of Braunan, Twitchell, and Andrus Island.

On February 26 the levee on the east bank of the Sacramento River, about 4 miles south of the city of Sacramento was broken. This break, which is known as the Edwards Break, originally about 100 yards in width, steadily increased, notwithstanding attempts to close it, and was fully 1500 feet wide during the latter part of February and entire month of March. The effect of this break was to relieve the pressure upon the levees at the city of Sacramento; but, on the other hand, brought about the flooding of thousands of acres of valuable crops. The water poured southward and flooded the entire country east and south to Disappointment Slough. The Pierson district, probably because of excellent levees, escaped. Thus, the water of the Sacramento River, leaving its own channel, passed into the San Joaquin by way of the Mokelumne. The flooding of Bouldin Island, about 3000 acres of which was under a high state of cultivation, was thus traceable to the Edwards Break. The asparagus crop of California, that was almost ready for the canneries, is said by Prof. R. E. Smith, of the University of California, to have been damaged by the floods as follows: 2000 acres Bouldin Island, 400 acres Staten Island, 300 acres Jersey Island, or, in general, about one-half of the asparagus crop devoted to canning.

Venice and Mandeville islands are not wholly reclaimed. Roberts, Union, and the other islands on the lower San Joaquin escaped injury because of the comparatively low stage of the San Joaquin and its tributaries.

A vast amount of grain land contiguous to the river was overflowed, especially in the Colusa, Butte, American, and Yolo basins. In all, probably 50,000 acres of valuable grain land were flooded. One of the most serious breaks occurred in the Colusa basin, on the west bank of the Sacramento River, at Princeton. A large portion of the Yolo basin continued under water for many weeks. Some of the best fruit land, especially for early cherries, on the east bank of the Sacramento River, back of Courtland and south to Walnut Grove, was covered with water

to the depth of 10 feet or more. In all, it is probably safe to estimate that nearly half of the total area of the islands, or about 55,000 acres, and also 50,000 acres of grain land, as stated above, were flooded.

The highest and lowest water, mean stage, and monthly range at 202 river stations are given in Table VII. Hydrographs for typical points on seven principal rivers are shown

on Chart V. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*C. C. Cooper, Weather Bureau.*

CLIMATE AND CROP SERVICE.

By Mr. JAMES BERRY, Chief of Climate and Crop Service Division.

The following summaries relating to the general weather and crop conditions during March are furnished by the directors of the respective sections of the Climate and Crop Service of the Weather Bureau; they are based upon voluntary reports from meteorological observers and crop correspondents, of whom there are about 3000 and 14,000, respectively:

Alabama.—Prevalent warm and generally dry weather was favorable for preparatory work and for germination and growth, except in northern counties where too much rain fell; much upland corn planted, some up to good stands; some cotton planted; nearly all early vegetables up to good stands; strawberries beginning to ripen; peaches in northern counties were damaged by the freeze of the 27th and 28th, but otherwise fruit prospects continued good.—*F. P. Chaffee.*

Arizona.—Dry weather continued until the early part of the third decade, when the drought was relieved slightly by rain and snow. High temperatures prevailed during the first two decades, but there was considerable cold weather, with damaging frosts, during the third decade. Crops did well in the lower Colorado Valley, but elsewhere did not thrive, and the prospect was discouraging at the end of the month. Range stock suffered greatly from insufficient feed and water.—*M. E. Blystone.*

Arkansas.—First of month favorable for farm work; some corn and potatoes were planted and small grain sown in southern portion, and came up to good stands; excessive rains latter part caused suspension of all work; fall grains doing well; very little ground prepared for cotton and none planted; peaches and plums in blossom; some peaches in extreme northern portion of the State damaged by cold weather, but generally fruit suffered no material injury from cold weather.—*Edward B. Richards.*

California.—Heavy rains continued the greater part of the month in central and northern sections, with abundant snow in the mountain districts and lighter rainfall in the southern sections. Great damage was caused by high waters in the Sacramento and northern San Joaquin valleys. Thousands of acres of valuable grain lands and rich asparagus fields were flooded, and replanting will be impossible in many cases. High winds on the 9th and 10th also caused much damage to orchards and farm buildings.—*Alexander G. McAdie.*

Colorado.—Soil too dry in eastern counties until rain and snow at close of month; plowing about half finished elsewhere. Dryness and high winds delayed seeding and damaged winter grain. Fruit trees were far advanced, and were injured somewhat by cold near close of month. Considerable snow fell in mountain districts, materially increasing the store of moisture; springs are revived, a good waterflow is indicated for the early season, and the late flow will probably be somewhat increased.—*F. H. Brundenburg.*

Florida.—Warm and mostly dry weather characterized the month. Farm work was well advanced. The early corn was worked. The bulk of the cotton crop was planted during the last decade; some early seeding was chopped; planting continued, however, at the close of the month, and the acreage will be materially increased. Pineapples suffered from the dry weather, and much citrus bloom was lost. Strawberries were plentiful and vegetable shipments active.—*A. J. Mitchell.*

Georgia.—The month was characterized by generally warm weather and light rainfall, the average precipitation being the lowest on record for March. Frequent rains in the northern section retarded farm work; elsewhere planting was well advanced at the close of the month. Corn planting was general in central and southern districts. Cotton seeding was confined to the southern half of State. The peach crop was injured but little, if at all, by frost.—*J. B. Marbury.*

Idaho.—The temperature was slightly below the normal, while the precipitation average was the greatest on record for any month; snow in the mountains attained an unusual depth, roads in valleys were very muddy throughout the month, and little farm work was done. Trees, hay crops, and winter grain were reported in excellent condition. Range grass started well; stock mostly in fair condition, though there was some loss of sheep from heavy rain and snow.—*Edward L. Wells.*

Illinois.—Wheat showed decided improvement, having reached nearly average development in the southern district, where the crop was least promising during the winter. Rye was in a thrifty stage. The season was very backward and the soil too wet for spring plowing. Only a few fields had been sown with oats. Pastures and meadows were generally promising. Peach buds were conceded to be mostly killed or injured, but other fruits, especially apples, were believed to be unscathed.—*Wm. G. Burns.*

Indiana.—Wheat improved during the month and was generally in fair condition at the time of the occurrence of excessive rains on March 25-26, which badly washed all fall sown crops on rolling and hill lands and flooded those on creek and river bottoms. At the close of the month the bottoms of the lower reaches of the White and Wabash rivers were still flooded and the entire loss of a large acreage of wheat seemed probable.—*W. T. Blythe.*

Iowa.—March was a typical spring month, in respect to temperature and precipitation, with less than the usual number of severe storms; but conditions were generally unfavorable for seeding and other field work. In a few favored localities oat and spring wheat seeding was begun. The ground was frozen to an unusual depth, and the frost yielded slowly, leaving the surface quite wet. Farm stock doing well. Fall wheat and rye damaged.—*John R. Sage.*

Kansas.—Wheat improved rapidly in eastern, less rapidly in central, and was poor in western counties. Oats were sown and coming up in southern districts and sowing had progressed in the central and begun in the northern counties. Plowing was completed in the southern and was progressing in the central counties. Corn planting had progressed well in the southeastern counties and had begun in the central-eastern. Peaches, apricots, pears, and plums were blooming in the southern counties.—*T. B. Jennings.*

Kentucky.—The rainfall averaged considerably above normal for the month. In some localities it was very heavy, causing considerable damage to crops by washing and flooding. The temperature was slightly above normal. The outlook for fruit was quite good. Wheat had improved considerably, but was still unsatisfactory. Tobacco beds were sown and plants were coming up in the early ones at the end of the month. Grass was starting well. Farm work was late.—*H. B. Hersey.*

Louisiana.—Occasional showers well distributed over the State proved exceptionally favorable for farming interests. Preparations for the cotton crop were unusually well advanced and planting was well under way over the southern portion of the State. Sugar cane was doing well, except that fall planting was backward. Rice seeding was being pushed forward. Corn was coming up to good stands and early planted was being cultivated. Berries are of good quality and the crop is heavy. Trucking interests were well advanced.—*I. M. Cline.*

Maryland and Delaware.—Temperature and sunshine were below normal; precipitation was slightly deficient, though rainy days were in excess. The ground was frozen until the last decade and then too wet for plowing, except on uplands. The weather was favorable for grain and grasses, which made great improvement generally, and for care of last year's tobacco. Late wheat was in very poor condition. Some potatoes, peas, and gardens were planted, and clover seeding was nearly completed.—*Oliver L. Fassig.*

Michigan.—Winter wheat and rye seemed to have wintered fairly well. At the close of the month wheat and rye tops were somewhat brown, but the roots were apparently healthy; on low, heavy land excessive moisture damaged wheat. Fruit buds as far as could be determined were generally in good condition. At the close of the month frost was still in the ground and field work had not begun.—*C. F. Schneider.*

Minnesota.—Coldest weather occurred generally on the 3d, when all minimum temperatures were below zero; temperatures were again below zero in northern counties as late as the 27th, but the weather was less severe from the 6th to the 26th. Precipitation occurred on many days; the northern districts were covered with snow the entire month, and the southern until the 24th. A little wheat was sown on light high lands in the southwestern and central-western districts on the 31st.—*T. S. Outram.*

Mississippi.—Conditions were very favorable, except heavy rains north during the last decade, and frosts on the 27th and 28th. Farm work was unusually well advanced, except in the extreme northeastern counties, where labor was scarce. Oats did well. Much corn was planted and some was up to good stands in the southern counties. Cotton planting began. Garden truck and fruit were generally promising, although damaged somewhat by frosts north. Vegetables and strawberries were being shipped from the south.—*W. S. Belden.*

Missouri.—The month was generally favorable for winter wheat, which improved decidedly in nearly all sections. In the southwestern counties oats were nearly all sown, considerable plowing was done for corn, and a little corn was planted up to the 24th, but elsewhere very little farm work was done, the soil being too wet. Excessive rains in the southeastern counties on the 24-25th washed fields badly and caused floods which did much damage to crops and property.—*A. E. Harkett.*

Montana.—The coldest weather occurred in the first and last decades;